

THE MOLLUSCA OF THE RANIKOT SERIES¹

BY

M. COSSMANN AND G. PISSARRO.

INTRODUCTORY NOTE ON THE STRATIGRAPHY OF THE RANIKOT SERIES.

BY

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The following brief notice regarding the stratigraphy of the Ranikot beds has been written at the request of the distinguished authors of the present monograph in which they describe the molluscan fauna of this geological formation.

The annexed table gives a list of the geological formations that occur in Western Sind.

The name "Ranikot series" was selected by Blanford in 1876 (*Rec., G. S. I.*, Vol. IX, p. 9), for the lowest of the stratigraphical divisions constituting the eocene of Western Sind. The name is derived from a large fortified enclosure¹ in the Laki range, where one observes a fine development of the lower beds of the group, consisting principally of fluviatile sandstones: the series is divisible into two main portions, a lower thicker one without marine fossils, and an upper one consisting of marine beds. The upper marine beds are irregularly overlapped by the Laki series of middle eocene age, and there is a certain amount of erosion unconformity, so that sections occur in the Laki range where the upper marine division is entirely absent, this being particularly the case at Ranikot itself.

Unlike the underlying Senonian and the overlying Middle Eocene and Oligocene which are developed on a vast scale throughout the whole length of extra-peninsular India, and in some of the coastal regions of the peninsula, the Ranikot series is of very limited occurrence and is entirely unknown outside of a relatively small area in Western Sind where it outcrops mainly in three disconnected patches; these are a very narrow elongated outcrop in the Laki range, this outcrop forming the axis of a broken anticline; the Band Vera plain north-west of Kotri where the Ranikot series appears in a shallow, elliptical, dome-shaped anticline; another shallow anticline in the neighbourhood of Jhirak, of which only the western portion is visible, the eastern limb disappearing beneath the Indus alluvium. The structure of this last outcrop should perhaps be regarded not really as an anticline, but rather as a monoclinal flexure, for

¹ It is as well to notice that "Ranikot" should not be spelt or pronounced with an accented *a*, and does not therefore signify "the queen's castle" as one might be tempted to imagine. It is compounded with the word *Ran* which signifies a wilderness or desolation, a familiar meaning in the case of the desolate area known as the "Rann" of Kachh. The name means therefore "fort-desolation" or "the fortress in the wilderness."

in the easternmost exposures of this outcrop, the strata are invariably horizontal without any indication of easterly dips. The flexure would then constitute the eastern limb of the shallow synclinal bend situated west of Meting and Jhinpir. A small outcrop of Lower Ranikot beds appears in a subsidiary anticline west of the Laki range anticline at Waud Dadn about 4 miles west of Ranikot. These outcrops are shown on the accompanying map which embodies the latest results of the geological researches in Sind. (Fig. 9.) The diagram, fig. 8, exhibits a scheme of the main structural features of the region, showing the position of the anticlinal axes.

Of the three principal outcrops, the northern one consists principally of Lower Ranikot beds, the upper marine beds being mostly absent in consequence of the overlap of the overlying Laki series. The Band Vera anticline, in its central portion where most deeply affected by erosion, exhibits the upper portion of the lower fluviatile series surrounded by an irregular halo-shaped outcrop of the upper marine beds. The southern outcrop only exhibits the upper part of the marine beds. The full thickness of the Lower Ranikot is only exhibited in the Laki range exposure, the full thickness of the Upper Ranikot in the Band Vera exposure. The maximum thickness of the Lower and Upper Ranikot has been estimated respectively at about 1,500 and 700 to 800 feet (about 450 and 200 to 250 metres).

The Lower Ranikot consists principally of sandstones and clays often of brightly variegated colours principally brown and red. (Fig. 1.) Except for an oyster bank at its base it is destitute of marine fossils, but certain beds contain impressions of dicotyledonous leaves, sometimes in a fine state of preservation. Towards the upper portion of the series, a seam of lignite of workable thickness was accidentally discovered during the excavation of a well at Leilan in the Band Vera plain, but it was observed to thin out within a short distance. The Laki range is an unsymmetrical anticline with very steep dips along its eastern limb, and whose deflected axis, throughout a considerable portion of the range, has been fractured by overthrust. Consequently a much deeper section is exposed in the western limb of the anticline than in the eastern one where the lower rocks are faulted down out of sight. Towards both extremities of the range, that is north of Laki and from the neighbourhood of Ranikot southwards, the Laki range becomes a simple anticline, still deflected to some extent, but no longer fractured.

The base of the series is visible only in the more strongly dislocated portion of the outcrop, for a distance of 13 miles (about 20 kilometres) southwards from Laki, and again, in two smaller patches between the termination of the first outcrop and Ranikot, and lastly, for a space of a few square yards only at Ranikot itself where the Rani or Mohan river cuts through the axis of the anticline which at that place runs clear of the fault. (Fig. 2.) The fault at Ranikot has greatly decreased in intensity and has been shifted a little east of the anticlinal axis. The total distance from Laki to Ranikot is about 22 miles (about 35 kilometres). The base of the series is also exposed in the subsidiary anticline west of Ranikot (see fig. 5).

1 "Panth Vera is a diim or "bind" across a hollow, for the purpose of storing water for irrigation. After rain there is a large reservoir, but in dry seasons there is no water." *Mem. G. S. J., Vol. XVII, p. 145*

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'FOSSIL FAUNA OF THE RANIKOT.



E. W. Vredenburg Phot.

FIG. 1.—FLUVIATILE SANDSTONES AND SHALES OF THE LOWER RANIKOT.
CAPPED BY ALVEOLINA LIMESTONE, RANIKOT.
Looking North-West

FOSSIL FAUNA OF THE RANIKOT



FIG. 2.—ANTICLINE OF DECCAN TRAP AT RANIKOT.

Looking North by West.

E. W. Vredenburg Phot.

Wherever the base of the series is visible, it is observed resting on a bed of basalt belonging to the Deccan Trap series. This bed has all the characters of a sub-aërial flow, and indicates an interval of continental conditions between the underlying and overlying formations. (Fig. 2).

Under Jakhmari peak, near the northernmost extremity of the Laki range exposure, and in the inlier west of Ranikot, there intervenes, between the basalt and the fluviatile series, a thin oyster bank. At Ranikot itself, and at many other places, the oyster bank is not observed. It may be regarded as the base of the Ranikot series, representing a very short return of marine conditions, preluding to the establishment of estuarine or fluviatile conditions that prevailed during the Lower Ranikot. It is as well, however, to keep in sight the possibility of its being intermediate in age between the basalt and the true commencement of the Upper Ranikot, and representing therefore a very short episode of marine transgression, separated by a period of no sedimentation both from the underlying basalt and the overlying Ranikot. I mention this possibility because of a similar feature which recurs in Sind at a subsequent geological period in the shape of another zone of oyster banks that has often been regarded as constituting the base of the Manchhars, because it is sometimes found intervening between them and rocks of much older age, such as eocene limestones. It has been recognised, however, that the oysters in this sub-Manchhar banks are *Gāj* species, the Manchhars themselves containing, in their lowermost beds, vertebrate remains of Pontian age. Their apparent connection with the oyster bed is therefore an illusion due to a short period of maximum marine transgression probably of uppermost Aquitanian age. When I visited the sections exhibiting the sub-Ranikot oyster bank at Jakhmari and west of Ranikot, and also the sub-Manchhar oyster banks at various points in Sind, I was still under the impression of the stratigraphical continuity of the *Gāj* and Manchhar as stated in the official publications of the Geological Survey; I therefore looked upon the sub-Manchhar oyster-banks as truly connected with the Manchhars, and unhesitatingly applied the same interpretation to the sub-Ranikot oyster bank which I regarded as connected with the overlying Ranikot, and did not pay special attention to such stratigraphical features as might have settled the independence or otherwise of these formations. The recognition in the districts of Baluchistan adjoining Sind, of a vast accumulation of Burdigalian and Helvetian strata intermediate in age between the *Gāj* and Manchhar, entirely disposes of the possibility of these two formations being continuous (*Rec., G. S. I.*, Vol. XXXIV, pp. 92, 175).

Throughout the Laki range exposure, the Ranikot is overlaid by a massive white limestone with nummulites and alveolines which Blanford identified with the nummulitic limestone of the Khirthar range, but which is in reality much older and should be identified with the division described by Griesbach in Baluchistan as the "Alveolina limestone," forming, in Sind, the most conspicuous member of the "Laki group" which has now been separated from the newer Khirthar.¹ The Laki and Khirthar correspond respectively with the Lybian and Mokattam of Egypt.

¹ "Zonal Distribution of Indian Nummulites," *Rec., G. S. I.*; Vol. XXIV, pp. 85-94, and "Classification of the Tertiary System in Sind," pp. 172-198.

STRATIGRAPHY OF THE RANIKOT SERIES.

The three sections figures 3, 4, and 5, herewith published will help to convey an idea of the structure of the Laki range and the distribution of rocks constituting it. They show the northern and southern extremities of the Ranikot outcrop and its central portion at Barra hill where the lowermost beds known in Sind, the Maestrichtian Orbitoides-limestones are exposed.



Fig. 3—Section at Barra Hill.

a—Manchikar (Sawalik). b—Alveolina limestone (Laki). c—Lower Ranikot. d—Deccan Trap. e—Olive shales with *Cardita Beaumonti*. f—Pab sandstones. g—Limestone with *Orbitoides*.

At Barra hill and at Jakhmari, there intervenes between the uppermost beds of the available lower Ranikot sandstones and the overlying Alveolina limestone, a brown calcareous sandstone constituting a thin representative of the Upper Ranikot series. It contains marine shells amongst which *Calyptrophorus indicus*, Cossm. and Piss., is particularly abundant. At Ranikot itself, in the inlier west of that locality, and at many other points in the Laki range, the alveolina limestone rests directly on beds of Lower Ranikot age, in consequence of the overlap and erosion unconformity already referred to.

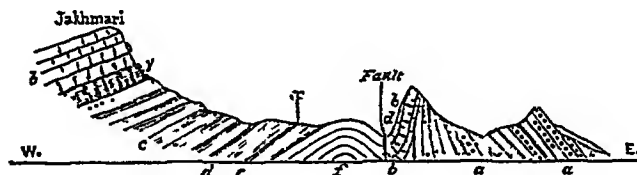


Fig. 4—Section at Jakhmari Peak (after Blanford)

a—Manchikar (Sawalik). b—Alveolina limestone (Laki). c—Lower Ranikot. y—Lowest beds of Upper Ranikot with *Calyptrophorus indicus*. d—Deccan Trap. e—Olive shales (x, *Cardita Beaumonti* bed). f—Pab sandstones.

A complete representation of the Upper Ranikot is exposed in the Band Vera antiline (Fig. 6) which forms an irregular ellipse with its major axis running from north to south, its dimensions being about twenty-five miles by ten (about forty kilometres by sixteen). An inner core of Lower Ranikot beds, of which, in consequence of the low dips, only the uppermost strata are exposed, is surrounded by concentric halos of the various subdivisions of the Upper Ranikot, and finally by an amphitheatre of low scarps of alveolina limestone. It is only the lower subdivisions of the Upper Ranikot whose outcrops constitute continuous rings; the upper beds, in the northern

part of the dome, that is the portion nearest the Laki range, are still affected by the Laki overlap, and it is only in the southern part of the ellipse, in the neighbourhood of Kotri and of a camping ground known as Petiani or Pethani, that the uppermost division is fully developed.

It is in the upper layers of the Lower Ranikot fluvatile sandstones of the Band Vera outcrop, near a locality known as Leilan, that the bed of lignite was discovered that first drew the attention of the Geological Survey of India towards the province of Sind. Shortly above the horizon of the lignite, there occurs the same brown calcareous limestone with *Calyptrophorus indicus* that has already been noticed in the Laki range. Above this zone, the Upper Ranikot whose total thickness in the Band Vera ellipse has been estimated as amounting to as much as 700 to 800 feet (about 210 to 240 metres) consists of numerous bands of dark brown limestones crowded with marine fossils, interstratified with sandstones and shales and clays, frequently gypseous which are often ferruginous and sometimes saline. The uppermost beds in the southern part of the ellipse are of a much paler tint, and approximate in appearance to the overlying Alveolina-limestone, with the result that, in the collections from the locality known as Petiani, there is a certain admixture of Laki and Ranikot fossils, which I have tried, as far as possible to sort out (see *Rec., G. S. I.*, Vol. XXXIV, pp. 186-188), though a few cases still remain doubtful. This confusion only affects the echinoids and does not extend to the Ranikot mollusca most of which were collected at other localities.

Foraminifera represented largely by alveolines, operculines, and orbitoides, (*Orithophragmina*) occur abundantly throughout the horizons succeeding the zone of *Calyptrophorus indicus*, but it is only in the upper zones that nummulites appear, represented at first by a minute *Assilina* which, in the uppermost beds of the neighbourhood of Kotri and Petiani, is accompanied by a fossil undistinguishable from the European *Nummulites planulatus*.

A feature that greatly puzzled the earlier surveyors is the presence of beds of iron ore of more or less lateritic appearance intervening between the Ranikot and the overlying middle coeene beds. Where the sections are sufficiently complete, its position at the base of the alveolina limestone is clear enough and was correctly interpreted, but when denudation has removed the overlying strata and left outlying patches of the ferruginous beds, their true stratigraphical position was not always recognised because they capriciously expand into dark ferruginous sandstones very dissimilar from the calcareous rocks of the Upper Ranikot and Lower Laki, and also because similar rocks occurring at the base of the Manehars are scattered irregularly over Lower Sind, and when disconnected by denudation from their overlying burden become as ambiguous of interpretation as the sub-Laki laterites.

The correct interpretation of these ferruginous accumulations which escaped the earlier surveyors, has proved a most valuable guide in unravelling the stratigraphy of Sind and Baluchistan. They correspond with periods of continental emergence otherwise unrepresented in the stratigraphy (see *Rec., G. S. I.*, Vol. XXXIV, pp. 179-180). The parallel stratification of all the successive

formations in Sind so effectually disguises the deficiencies of the geological series, that the whole sequence was interpreted by the earlier observers as perfectly continuous, and none of the stratigraphical gaps were clearly recognised except that at the upper limit of the Ranikot in the Laki range; but even this interruption was minimised as it was supposed to entirely fade away in a southern direction in the Band Vera and Jhirak exposures, an error largely due to a misinterpretation of the geological boundaries southwards from the neighbourhood of Kotri, south of the Band Vera ellipse, as far south as the neighbourhood of Tatta, that is for a distance of fifty miles (about 80 kilometres). Throughout this distance the rocks which I have distinguished as the Meting shales and which pass conformably upwards into the Alveolina limestone had been misinterpreted as the upper portion of the Ranikot. Consequently the Ranikot series has been regarded as passing gradually into the alveolina limestone. The ferruginous layer indicating the true position of the boundary was overlooked, or when observed, as in the neighbourhood of Jhirak, it was not followed up and its signification was not realised, it being regarded merely as a subsidiary band in the Upper Ranikot.

It will be noticed therefore that between Kotri and Jhirak, the map annexed herewith (Fig. 9) differs considerably from that illustrating Blanford and Fedden's work on the geology of Western Sind. The area occupied by Ranikot beds in Southern Sind appears now considerably restricted as compared with the previous map. The line shown in Blanford and Fedden's map as the upper limit of the Ranikot is a true geological boundary, but instead of corresponding with the upper limit of the Ranikot, it corresponds with the upper limit of the Meting shales. The true upper limit of the Ranikot must be shifted several miles further east, and the third of the principal Ranikot outcrops mentioned at the commencement of this note reduces itself to two small patches about Jhirak and some fifteen miles (about 24 kilometres) north-west of that town, the two patches being severed by an interval of Indus alluvium. Another exposure regarded by Blanford and Fedden as a further extension of the Ranikot outcrop, in the neighbourhood of Tatta has to be entirely suppressed, consisting as it does entirely of Meting shales.

It is gratifying to notice that this serious discrepancy has very little effect on the stratigraphical distribution of the fossils already described by Duncan and Sladen. It is evident that Fedden hesitated considerably as to the true boundary of the Ranikot in the Jhirak area, and the fossils have not been labelled in accordance with the boundary lines finally decided upon for publication; thus nearly all the echinoids from the Meting shale in the neighbourhood of Meting, though obtained from an area mapped as Ranikot are labelled as belonging to the middle eocene and have been described together with the middle eocene fauna by Duncan and Sladen. The confusion between the two faunas which I have attempted to unravel in a notice already alluded to (*Rec., G. S. I.*, Vol. XXXIV, p. 186), results almost entirely from the confusion in the collections from the neighbourhood of Petiani and Kotri at the southern extremity of the Band Vera outcrop, where

Laki and Ranikot fossils that have weathered out from the rocks near their junction are promiscuously scattered over the surface of the ground.

The outcrop erroneously referred to the Ranikot in the neighborhood of Tatta has yielded few fossils, but one of these is worth mentioning as its inclusion in the Ranikot fauna, and the vicissitudes of its synonymy have contributed to convey a wrong impression of the faunal characters of the Ranikot. This is an assiline which was described as an *Operculina* by Carter, and named by d'Archiac and Haime, *Operculina laticostis* and regarded as a variety of *Assilina spira* by Rupert Jones, who moreover confirmed Blanford's attribution to *Nummulites irregularis* of the true Ranikot nummulate which appears to me undistinguishable from *Nummulites planulatus*. The Tatta Assiline is not *A. spira* but *A. granulosa*, and as explained before does not occur in the Ranikot series but in rocks of later age, the Meting shales. The mention that has frequently been made of *Assilina spira* and *Nummulites irregularis* as characteristic fossils of the Ranikot is apt to give a very erroneous impression either of the age of the Ranikot, or of the stratigraphical value of these fossils.

I have dwelt upon these corrections not out of any desire to criticise the valuable work of my distinguished predecessor, but in order to dispel an apparent anomaly which has found its way into several important geological treatises.¹

The southernmost Ranikot exposure, as restricted according to the above corrections includes, as has already been noticed, only a small area in the immediate neighbourhood of Jhirak and to the south-west of that town. The rock is exposed in consequence of a very feeble anticlinal bulge, of which the western half is alone visible, with much shallower dips than even the Band Vera ellipse. Indeed it is only along the western border of the antiline, in the outcrop of the alveolina limestone that the dips are at all appreciable. Throughout the outcrop of the Meting shales and Ranikot beds, the rocks are almost or quite horizontal, the very gradual descent from Meting towards Jhirak and towards the banks of the Indus, causing successively lower horizons to appear in a series of miniature scarps.

As a consequence of this disposition, it is only the uppermost subdivisions of the Upper Ranikot that are exposed in this outcrop. There are two principal calcareous bands, of which the lowest, about six feet (about 2 metres) thick, is the more compact and consequently does not allow easy weathering of the fossils. It is extensively quarried. It is separated by about 50 feet (about 15 metres) of gypseous shales, from the upper band, a rubbly limestone largely consisting of reef-building corals and

¹ In *Rec., G. S. I.*, Vol. IX, p. 10, Blanford claims parenthetically the determinations of all the foraminifera and echinoids: and his list of foraminifera is substantially that reproduced in all subsequent publications dealing with Sind. It follows that Blanford is responsible for the confusion that prevails with regard to the Cocene and Oligocene orbitoides, the onus of which usually devolves upon Feden. (R. Douville, *Mém. G. S. F.* No. 32, 1891, p. 28.) Regarding the subsequent confirmation by Prof. R. Jones of some erroneous determinations of nummulites, it may be mentioned that in the collection forwarded to him, each species was represented by an inadequately small number of specimens, which were sometimes very uncharacteristic. This is particularly the case with *Nummulites planulatus* erroneously referred to *N. irregularis* and represented by a few abnormal overgrown specimens, which, when considered apart from the generality of the samples might easily pass for the latter species.

crowded with the remains of mollusca and foraminifera. Amongst the latter one notices a small assiline which appears to be referable to *A. miscella*, d' A. and H., and *Nummulites planulatus* the same nummulite that characterises the uppermost beds of the neighbourhood of Kotri and Petiani.

Whilst in the exposures of the Laki range and Band Vera plain, the Upper Ranikot is immediately succeeded by the Alveolina limestone, there intervenes between this formation and the Upper Ranikot of Jhirak a group of calcareous shales, that thin out in a northerly direction where they finally disappear just before reaching Petiani and that I have distinguished as the "Meting shales." They are of small thickness and pass conformably upwards into the alveolina limestone, while they are separated from the underlying Ranikot by a lateritic layer indicating an interruption of sedimentation corresponding with a continental interval. They contain a rich fauna of echinoids whose connection is much closer with that of the fauna contained in the alveolina limestone than with that of the underlying Upper Ranikot. The characteristic nummulites are *Nummulites atacicus* and *Assilina granulosa* neither of which occur in the Ranikot, but which both extend into the overlying alveolina limestone.

The palaeontological indications of an interruption in the sequence agree therefore with the stratigraphical features. The easiest way of accounting for the interruptions between the various subdivisions of the eocene in Western Sind is by supposing a series of oceanic oscillations in a basin whose depth gradually increased in a southern direction. The Ranikot represents a slow transgression followed by a sudden regression after the deposition of the beds with *Nummulites planulatus*. The Meting shales, only known in the southern part of the area represent a gradual return of the ocean culminating in the middle eocene transgression which had two maxima corresponding with the Alveolina and Khirthai limestones.

The difference of depth of the Ranikot sea-floor between the Band Vera and Jhirak exposures must be represented approximately by the small thickness (30 to 40 feet or 9 to 12 metres) of the Meting shales. The presence of a fine series of reef-building corals indicates that the Ranikot fauna belongs essentially to the laminaria zone representing a maximum depth of water of not more than 100 feet (30 metres).

The Upper Ranikot exposures in the Laki range and in the Band Vera ellipse are somewhat unfavourably situated for geological investigation owing to the scarcity of drinking water in ordinary years. Collections of fossils have been obtained only from the following small number of localities:—

1. From the broken ground among the hills under Jakhmari peak, hills west of Amri, lowermost bed of the Upper Ranikot, with *Calypptrophorus indicus*; collected by Fedden in 1875-76 (G. 280/137) and Noetting in 1900 (K. 7/658 to 669).
2. Hotian "lak" (pass) 10 miles south of Ranikot, collected by Fedden in 1875-76. (G. 280/134.)
3. Two miles east of Kandaira, Vera plain east, lowermost beds of the Upper Ranikot, with *Calypptrophorus indicus*, collected by Fedden in 1874-75

- (G. 226/156) and 1875-76 (G. 280/131); also from two successively higher horizons marked G. 226/156 with operculines. and G. 226/155 (Fedden, in 1874-75), with small assilines.
4. North of Leilan coal-pit; lowermost beds with *Calyptrophorus indicus* (G. 280/132b); and from a higher horizon, marked G. 280/129, containing small assilines: collected by Fedden in 1875-76.
 5. Three miles east of the old coal-pit near Leilan, Vera plain east, amongst gypseous beds; two successive zones, one marked G. 280/126^a, and a slightly higher one marked G. 280/126', both containing operculines; also from a brown limestone with small assilines at a higher horizon, on the road to Unerpur (G. 280/127); collected by Fedden in 1875-76.
 6. "Said to come from the Zimmiwari dori (ravine). Hills east of the Leilan coal-pit and west-south-west of Bhian." (G. 280/128); specimens purchased; Fedden, 1875-76.
 7. "Hilly ground, north by east of Petiani, below the big scarp of white limestones, north-west of Kotri;" uppermost horizon with *Nummulites planulatus* (G. 280/135); collected by Fedden in 1875-76.
 8. Below the lower limestone band of Jhirak; collected by Vredenburg in 1900 (K. 8/269). (Fig. 8).
 9. Lower limestone band of Jhirak, with small assilines; collected by Fedden in 1875-76 (G. 280/124b) and by Vredenburg in 1900 (K. 6/790-840).
 10. Upper limestone of Jhirak; uppermost Ranikot with *Nummulites planulatus*; collected by Fedden (G. 280/124a) in 1875-76; and by Vredenburg (K. 7/123-203) in 1900.
 11. Same horizon, left bank of Indus opposite Jhirak (K. 7/296-337); collected by Vredenburg in 1900.
 12. Same horizon, on the road south-west of Jhirak (G. 226/165); collected by Fedden, 1874-75.

It is easy to distribute the fossils from these various localities and zones in stratigraphical order; the localities 7, 10, 11, 12, in the neighbourhood of Kotri and of Jhirak, correspond with the uppermost beds, those characterised by the presence of *Nummulites planulatus*. At the localities 1, 3, 4, that is the undersearp of Jakhmari peak and the northern and eastern parts of the Band Vera plain, the beds characterised by the abundance of *Calyptrophorus indicus* are stated by Fedden as being the lowermost fossiliferous zone of the Upper Ranikot. These lowermost beds are destitute of foraminifera. The beds intervening between the lowermost fossiliferous zone rich in *Calyptrophorus indicus* and the uppermost zone with *Nummulites planulatus*, can be divided into two portions of which the upper one contains numerous specimens of a small *Assilina* which ascends into the overlying zone with *N. planulatus*, but does not descend into the lower portion of the intermediate beds where the commonest foraminifer is a thin species of *Operculina*. To the upper portion of these intermediate beds belong the lower limestone of Jhirak, Nos. 8 and 9 of the above lists, the uppermost beds (G. 226-155) east of Kandaira (locality 3) and north and east of Leilan

(localities 4 and 5). The available palaeontological evidence is insufficient to fix the exact stratigraphical position of the locality No. 2. The remaining localities are indicated as intermediate between the *Assilina* horizon and the lowermost fossiliferous zones. In this way the fossiliferous zones may be distributed through the 700 or 800 feet (210 to 240 metres) of the Upper Ranikot in four divisions which may be numbered accordingly in ascending order. The fossils hitherto described are not distributed indifferently through these successive zones, but certain species are restricted to special horizons as has been shown in the case of the Echinoidea (*Rec., G. S. I.*, Vol. XXXIV, 1907, pp. 187-188).

In the case of the mollusca (gastropoda and cephalopoda) described by Messrs. Cossmann and Pissaro, the zonal distribution is less evident, the reason being that the greatest portion of the collection is from a single zone, the zone of *Nummulites planulatus* which includes no less than 73 out of 100 forms described in the following monograph.

A considerable portion of the collection described in the present memoir was obtained by me during a search of six days in 1900 at Jhirak, where only zones 3 and 4 are exposed, the latter being by far the most fossiliferous. Amongst the material obtained in 1900 there are 40 species unrepresented in the older collections. The total number of species (gastropoda and cephalopoda) represented in my collections from Jhirak and the immediate neighbourhood is 65. Fedden's collection from the same locality includes 30 species of which 10 are unrepresented in mine. Consequently the total number of forms collected at Jhirak is 75, including three-quarters of those hereafter described, and amongst these there are only two special to the lower limestone (zone 3) so that this memoir is practically a description of the fauna of Jhirak, specially of the uppermost horizon.

Out of 100 forms, seventy-three occur, as stated, in this highest horizon, zone 4. Of the twenty-seven remaining ones, seven are special to zone 1 (with a total fauna of 12, species); 11 to zone 2 (with a total fauna of 25 species); 7 to zone 3 (with a total fauna of 15 species); one, *Cerithium subsemicostatum*? is common to zones 2 and 3, one, *Turritella infrarimata* is of doubtful position. The three lower zones have each of them, therefore, half their species autonomous. With the exception of the above mentioned fossil common to zones 2 and 3, all those that are not special to the three lower zones occur also in zone 4. The latter has 53 species special to it out of a total of 73, but this large proportion is due to its preponderating share in the collection.

A representation, in tabular form of the zonal distribution of the molluscan fauna would, under the circumstances, be premature, as it is impossible to tell to what extent the apparent zonal distribution depends upon the insufficiency of the material studied.

In the case of the echinoids, although the collections from the uppermost zone are the richest, the distribution through the successive zones is less unequal than in the case of the mollusca: they are not particularly plentiful at Jhirak, and I have not materially added to the previous collections. Their zonal distribution already recorded in a previous publication of the Geological Survey is here reproduced, and, to give

as complete a picture as possible of the Ranikot fauna so far as known at present, I have added the corals determined and described by Duncan, also distributed according to their zonal apparition.

ZONAL DISTRIBUTION OF THE RANIKOT ECHINOIDEA.

	UPPER RANIKOT			
	Zone 1, with <i>Calyptrophorus indicus</i> .	Zone 2, with <i>Operculina</i> sp.	Zone 3, with <i>Asterina maculata</i> .	Zone 4, with <i>Stenaster planatus</i> and others.
<i>Oidaris</i> sp., D. and S., p. 25	
„ <i>Vernaculi</i> d'Aroh.	
„ sp., spines, G. $\frac{280}{185}$, D. and S., p. 30	
„ sp., spines, G. $\frac{280}{125}$, D. and S., p. 50			
<i>Phyllacanthus sindensis</i> D. and S.	
„ <i>Ranikoti</i> D. and S.			
„ sp., D. and S., p. 28.	
„ sp., spines, D. and S., p. 50		
<i>Salenia Blanfordi</i> D. and S.	
<i>Cyphosoma abnormale</i> D. and S.	
„ sp., D. and S., p. 33	
„ sp., D. and S., p. 34	
<i>Acanthechinus nodulosus</i> D. and S.			
<i>Dictyo pleurus sicca</i> D. and S.	
„ <i>Haimi</i> D. and S.			
„ <i>d'Archiaci</i> D. and S.		
<i>Arachniopleurus reticulatus</i> , D. and S. ¹	
<i>Progonochinus coccineus</i> D. and S.			
<i>Eurypneustes grandis</i> D. and S.	
<i>Eolopneustes de Lorioli</i> D. and S.	
<i>Canoclypeus sindensis</i> D. and S.	
„ sp., D. and S., p. 52		
„ <i>declivis</i> D. and S.		
<i>Phylloclypus</i> sp. ²			
<i>Plesiolampas placenta</i> D. and S.		

¹The form described under this name in the Lahl group (Martin and Duncan Fehlnoiden of Kachh and Kathiawar, (1883), p. 11; Vredenburg, Die wech-selnde Deser., *Mém. O. S. I.*, Vol. XXXI (1901), p. 201) is a very distinct variety, which might rank perhaps as a separate species.

²This generic attribution is doubtful.

Zonal Distribution of the Ranikot Echinoida—contd.

	UPPER RANIKOT			
	Zone 1, with <i>Colaptychus</i> nucleus	Zone 2, with <i>Operculosa</i> sp.	Zone 3, with <i>Aspidina</i> sub- erica	Zone 4, with <i>Yucculites</i> <i>planulatus</i>
<i>Pleurolampas pectolopha</i> D and S		
" <i>ovalis</i> D and S		
" <i>rosaria</i> D and S	
" <i>polygonalis</i> D and S	
<i>Eolampas antecursor</i> D and S				
<i>Echinanthus enormis</i> D and S				
<i>Cassidulus ellipticus</i> D and S	
<i>Eurhodia Morrisoni</i> , d'A and H.	
" " <i>var.</i> , D and S, p 72			
<i>Paralampas jilens</i> D and S			
" <i>minor</i> D and S				
<i>Neorotopygus rotundus</i> D and S			
<i>Hemiaster elongatus</i> D and S			
<i>Linthis indica</i> D and S		
" <i>sp.</i> , D and S, p		
<i>Friaster aevolatus</i> D and S		

ZONAL DISTRIBUTION OF THE RANIKOT CORALS.

	UPPER RANIKOT			
	Zone 1, with <i>Colaptychus</i> nucleus	Zone 2, with <i>Operculosa</i> sp.	Zone 3, with <i>Aspidina</i> sub- erica	Zone 4, with <i>Yucculites</i> <i>planulatus</i>
<i>Trochocyathus corbicula</i> , Dunc.			
<i>Placocyathus striatus</i> , Dunc.			
<i>Bligotia simplex</i> , Dunc.			
<i>Trochomelia Medicotti</i> , Dunc.	
<i>Stylinia Reusii</i> , Dunc.	
<i>Stylocrania maxima</i> , Dunc.	
" <i>Ficeryi</i> , Hamo	

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Zonal Distribution of the Ranikot Corals—contd.

	UPPER RANIKOT.			
	Zone 1, with <i>Calyptraphorus indicus</i> .	Zone 2, with <i>Operculina</i> sp.	Zone 3, with <i>Asulina micella</i> .	Zone 4, with <i>Xyomelastrea planulata</i> .
<i>Stylocenia Ranikoti</i> , Dunc		
<i>Montivallia Granti</i> , d'A and H.	..			
" <i>Lynsani</i> , Dunc	..			
" <i>Ranikoti</i> , Dunc.		
<i>Feddenia typica</i> , Dunc	..			
" <i>cristata</i> , Dunc.		
" <i>elongata</i> , Dunc.	..			
<i>Florophyllia simiani</i> , Dunc.	
" <i>flabellata</i> , Reuss.	..			
<i>Diploria flexuossima</i> , d'Achard	
<i>Leptoria hydnochoroides</i> , Dunc		
<i>Stephanocania mureotuberculata</i> , Dunc.	
<i>Astrocrania Blanfoidi</i> , Dunc.	..			
" <i>cellulata</i> , Dunc.	
" <i>nana</i> , Reuss.	
" <i>gibbosa</i> , Dunc.	
" <i>ramosa</i> , Sowerby	
<i>Isastraea punctata</i> , Dunc		
<i>Astraea Morlati</i> , Reuss.	
<i>Prionastraea imbecilis</i> , Dunc.	
<i>Reussastraea granilis</i> , Dunc.	
<i>Pachyseris Murchisoni</i> , M Ed. & J. Haimo	
<i>Trochoseris difformis</i> , Reuss	
<i>Cynthoseris orientalis</i> , Dunc.	
<i>Elliptoseris aperta</i> , Dunc.	
<i>Turbinoseris Ranikoti</i> , Dunc.		
" <i>cythocarpa</i> , Dunc.	..			
" <i>Haimi</i> , Dunc	..			
" <i>indica</i> , Dunc.	..			

Zonal Distribution of the Ranikot Corals—contd.

	UPPER RANIKOT			
	Zone 3, with <i>Cyathophorus</i> <i>vicinus</i>	Zone 2, with <i>Operculina</i> sp.	Zone 1, with <i>Asulina</i> <i>mac-</i> <i>ellia</i> .	Zone 4, with <i>Nummulites</i> <i>planulatus</i>
<i>Turbinosera elegans</i> , Dunc	
<i>Cyclolites alpina</i> , d' Orb	..			
" <i>Ranikoti</i> , Dunc	..			
" <i>Ranikoti</i> Dunc var.	
" <i>crenulata</i> , Dunc	..			
" <i>Picaryi</i> , Haime	..			
" <i>anomala</i> , Dunc.	
" <i>superba</i> , Dunc.	..			
" <i>Haime</i> , Dunc	..			
" <i>altavillensis</i> , DeFr.		
" <i>striata</i> , Dunc.	
<i>Thamnastræa Balli</i> , Dunc	
<i>Stephanophylla indica</i> , Dunc		
<i>Latharæa grandis</i> , Dunc.		..		
<i>Porites superposita</i> , Dunc		

Only two foraminifera have been identified, *Assilina miscella*, d'A and H. occurring in zones 3 and 4, and *Nummulites planulatus* restricted to the uppermost zone. The latter fossil is of importance as it constitutes a basis for the correlation of the Ranikot group: it is the oldest of the common nummulites in Europe where it characterises a very well defined horizon, that of the Sables de Cuise, slightly newer than the London Clay. We may therefore conclude that zone 4 of the Upper Ranikot corresponds with the Cuisian proper, while the three underlying horizons may be taken as approximately corresponding with the London Clay. The Lower Ranikot might therefore correspond with the Woolwich and Reading beds, and its lithological resemblance to that subdivision is not out of keeping with this assimilation, while the lignite bed of Leilan also suggests a comparison with the lignitiferous Sparnacian of the Paris basin. The propriety of uniting with the Lower Ranikot, the oyster bank at the base of the series requires further investigation. Perhaps have we in it a feeble representative of the Thanetian.

Beds of lower eocene age are not known anywhere else in India outside the limited area briefly described above. In all instances where certain stratigraphical groups have been assimilated with the Ranikot, closer investigation has shown that

they should be regarded as middle eocene. The presence in the Oman coast of Arabia of *Styracothentis orientalis*, Crick, a very characteristic fossil of the uppermost Ranikot zone, suggests the presence, in that region, of beds of corresponding age. The scarcity of lower eocene outcrops as compared with the vast development of the Senonian and Lutetian is by no means peculiar to India, but seems to be shared by most other countries.

Their exceptionally fine development in the Anglo-Parisian basin in the very focus of active geological work, is apt to convey a mistaken impression of their importance.

In connection with the occurrence of the Ranikot just beyond the fringing folds of the Iranian arc, and also in the unfolded plateau-like region of Arabia, it is worth noticing that the fullest development of the lower eocene appears to be almost entirely outside the limits of geosynclinal areas.

THE MOLLUSCA OF THE RANIKOT SERIES.

BY

M. COSSMANN AND G. PISSARRO,

TRANSLATED FROM THE FRENCH. BY E. W. VREDENBURG.

PART I.—CEPHALOPODA AND GASTROPODA.

INTRODUCTION.

The Geological Survey of India have done us the honour of entrusting to our care, for description and publication, their valuable collection of mollusca from the Ranikot series of Sind. We have been engaged upon this work during the last few years, and have completed the description of the Cephalopoda and Gastropoda in 1907.

Before entering upon the detail of our palæontological results, we may briefly summarise the conclusions that we have arrived at regarding the stratigraphical position of the beds from which these fossils were obtained. These conclusions are in thorough agreement with the classification recently published by Mr. Vredenburg, in Volume XXXIV of the *Records of the Geological Survey of India*, pages 172-198.

After reviewing the classification of the Tertiary beds in Western Sind as outlined in 1878 by Blanford, according to whom the Ranikot beds are to be regarded as lower eocene, Mr. Vredenburg has come to the conclusion that, in consequence of the stratigraphical interruptions which he has detected, the age assigned to the immediately overlying beds should be slightly raised, and that attributed to the immediately underlying strata, that is the "Cardita Beaumonti beds" slightly lowered. The "Cardita Beaumonti beds" are now regarded as undoubtedly cretaceous, reaching down into the Maestrichtian, a conclusion similar to that already arrived at by Mr. Douvillé in the case of Persia. In the case of the Ranikot, Mr. Vredenburg has noticed that the first appearance of the nummulites (represented by *N. planulatus*) occurs only in their uppermost beds, confirming Blanford's original attribution of the marine beds of this series to the lower eocene, that is the Ypresian or Cuisian.

Amongst the fossils which we have examined, there are numerous specimens of *Velates*, a genus which specially characterises the lower eocene of Europe. The presence of some species of *Calypthophorus* analogous to those from the eocene of the United States, the relative abundance of forms of *Volutalithes* (or as it is now called

"*Volutospina*"), the presence of numerous species of *Ampullina*, a genus scarcely known in the miocene, the existence of several forms of *Rimella* related to those of Paris and Cairo, etc., entirely confirm the conclusions arrived at by the stratigraphers of the Geological Survey. This fauna is evidently related to a portion of that described by d'Archiac and Haime. It is now well established that the collections described by these authors were obtained from several totally distinct horizons, but the species which we have identified with the Sind fossils of the Geological Survey collection (22 species) are exclusively mentioned as occurring in the yellow limestone of the "Hala range", a name often used by geographers as a general designation for the mountains of Western Sind. The yellowish-brown limestone forming the matrix of our fossils answers closely to d'Archiac's description, and it is probable that the fossils collected by the Geological Survey were, in many cases, obtained at the very same spots where Vierey discovered the fossils described in our distinguished predecessors' great monograph.

The state of preservation of most of the fossils is satisfactory: in only a few cases have we experienced any doubt in our generic references; we hope that the discovery of fresh material will eventually settle the few points that still remain uncertain from a palæontological point of view.

Class: CEPHALOPODA.

Order: DECAPODA.

The Decapoda are represented in the Ranikot beds by the genera *Belosepia* and *Styracothentis*, of which the latter is particularly interesting owing to its relation to the Belemnites.

Family: *SEPIOPHORÆ* Fischer.

Genus: *BELOSEPIA*, VOLTZ, 1830.

BELOSEPIA INCURVATA, sp. nov., Pl. I, figs. 11-13.

Description.—The size is moderate, the shape compressed. The recurved rostrum is very short, rounded on the ventral side, somewhat keeled dorsally. The phragmocone does not expand much anteriorly; its external surface carries coarse granulations. There is an obsolete apophysis, scarcely indicated by a bend in the outline.

Dimensions.

Height	.	.	.	.	.	.	.	.	.	.	.	.	30 mm.
Thickness	.	.	.	.	.	.	.	.	.	.	.	.	11 "

Occurrence.—Found in the uppermost Ranikot beds of Jhirak. (Vredenburg $\frac{K.7}{207}$.)

Comparison with other species.—The short, hook-shaped, laterally compressed rostrum clearly distinguishes this species from its congeners of the Paris basin. It somewhat resembles the claw of a hyena owing to the continuous curve of its dorsal outline. The dorsal lamella is unfortunately damaged in the type-specimen.

Family: *PHRAGMOPHORA* Fischer.

Genus: *STYRACOTHEUTIS*, Crick, 1905.

The genus *Styracothautis* seems related both to *Bayanotheutis* Munier-Chalmas (1872), and *Vasseuria* Munier-Chalmas (1880). According to Mr. Crick by whom it was lately established,¹ this genus differs from *Bayanotheutis* "firstly, by the more conical form of the guard, secondly, by the presence of the deeply incised groove on each side of the ventral surface; and thirdly, by the more nearly dorsal position of the broad shallow dorso-lateral grooves." Compared with *Vasseuria*, it "is much larger than this genus, its two longitudinal grooves are deepest at the alveolar margin, and do not extend to the posterior extremity, whereas in *Vasseuria* the longitudinal grooves extend from the apex and die out on the alveolar region. *Vasseuria* also does not possess any dorso-lateral depressions." Mr. Crick has also compared his new genus with *Belemnitella mucronata* of the Upper Chalk: "Well preserved examples of *Belemnitella mucronata* possess, on each side, a double dorso-lateral groove, in which the groove adjacent to the dorsal area is much broader than the other, and anteriorly approaches its fellow on the opposite side, imparting to the alveolar region of the guard a subtriangular cross-section. The other groove on each side, i.e., the groove nearer the middle of the lateral area, is much narrower, and from it originate the vascular impressions which pass on to the ventral surface of the guard, where they form a very conspicuous character." Mr. Crick goes on to say that in *Styracothautis*, "each dorso-lateral depression appears, then to be comparable with the more dorso-lateral component of each double dorso-lateral groove in the genus *Belemnitella*, while the incised grooves bounding the ventral surface appear to be comparable with the more nearly lateral component of each dorso-lateral groove in the same genus." Finally it is concluded that *Styracothautis* is "generically distinct, and whilst being more nearly related to such eocene forms as *Bayanotheutis* and especially to *Vasseuria*, forms a connecting link between these genera and the Cretaceous genus *Belemnitella*."

STYRACOTHEUTIS ORIENTALIS, Crick, Pl. I, figs. 5-10.

Description.—The size is moderate, the shape elongate, belemnitoid, gradually tapering towards the posterior extremity which terminates in a blunt point. The section is elliptical, the average ratio between its two axes being five to six. The

¹ "On a Dibranchiate Cephalopod, *Styracothautis orientalis*, n. gen. and n. sp., from the Eocene of Arabia" *Proc. Malac. Soc. Lond.*, Vol. VI, pp. 274-278 (Figs.)

dorsal surface is coarsely shagreened, simulating a corroded appearance; it is traversed by very deep longitudinal grooves which do not reach up to the apex, and between which are intercalated finer and somewhat irregular grooves. The ventral surface distinctly shows the siphuncle situated in a channel limited by a swelling of the adjacent substance on either side. Traces of the transverse septa can be detected on the internal surface.

Dimensions.

Height of figured fragment	. . . . .	39 mm.
Greatest diameter	. . . . .	12 "

Occurrence.—In the uppermost Ranikot beds, zone of *Nummulites planulatus* Jhirak (Viedenburg, ⁶⁹); north-east of Petiaui (Fedden, ⁹²⁻⁹³). Fedden's specimens are very fragmentary and are not mentioned in the lists of fossils published by him and by Blanford in connection with the description of the geology of Western Sind. They must have escaped notice, as their real nature was not understood. The material studied by us was all collected at Jhirak in 1900 by Mr. Viedenburg. Both Mr. Viedenburg and Dr. Noetling recognised the affinities of this fossil with belemnites. [General Report of the Geological Survey of India for 1900-1901, page 3, (1901). General Report for 1901-1902 page 36 (1902).]

Remarks.—The Indian examples are somewhat more compressed than the solitary specimen from Arabia that constitutes the type of the genus, but this slight difference does not seem sufficient to justify a specific distinction. The specimen described by Mr. Crick was obtained by Colonel Jayakar from the eocene beds of Sharkiyab in the territory of Oman in Arabia. It is abundant in Sind, but usually in a fragmentary condition, fairly complete specimens with unbroken apex and a perfect phragmocone being seldom met with. The occurrence of this fossil in Sind and in Oman is of great interest as indicating the presence of contemporaneous strata of lower eocene age on both shores of the Arabian Sea.

Order: NAUTILOIDEA.

Family: NAUTILIDÆ.

Genus: NAUTILUS, Breynius.

NAUTILUS SUBLEURASIANSUS, d'Arch., Pl. I, figs. 1-4.

1850 D'Archiac, *Histoire des progrès de la Géologie*, Vol. III, p. 301.

1873 D'Archiac and Haim, *loc. cit.* p. 377, Pl. XXXV, figs. 1, la

Description.—Size very variable; shape depressed, not much inflated; surface plain, with faintly visible indications of the septa; umbilicus small, shallow in young specimens, very deep in adults; siphuncle situated centrally; chambers numerous; septa flexuous except near the umbilicus.

¹ In this and in subsequent references, *loc. cit.* stands for d'Archiac and Haim's "Description des animaux fossiles du groupe nummulitique de l'Inde."

Dimensions of figured specimen.

Diameter	.	.	.	.	.	.	.	.	.	.	.	57 mm
Thi knee	.	.	.	.	.	.	.	.	.	.	.	25 "

Occurrence.—This is a common fossil throughout the marine beds of the Upper Ranikot, and has been collected from each of the four zones into which this series has been divided by Mr. Vredenburg. Zone 1: north of Leilan coal-pit, one specimen, $\frac{62.40}{125.20}$ (Fedden). Zone 2: three miles east of the old coal-pit near Leilan, at two successive horizons; one fragment from the lower bed (Fedden, $\frac{62.40}{125.20}$), and two specimens from a slightly higher level (Fedden, $\frac{62.40}{125.20}$). Zone 3: hills east of Leilan old coal-pit on the road to Unerpur, four specimens (Fedden, $\frac{62.40}{125.20}$); Jhirak, three specimens (Vredenburg, $\frac{K7}{19.1}$). Zone 4: Jhirak, nine specimens (Vredenburg, $\frac{K7}{19.1}$); left bank of Indus opposite Jhirak, three specimens (Vredenburg, $\frac{K7}{19.1}$).

Comparison with other species.—D'Archiac has compared this fossil with the Cenomanian species *N. Fleuriusianus*, d'Orb. (*Paléont. franc.*, Vol. I. Pl. XV). Our specimens seem more compressed than is indicated in the original figure of d'Archiac and Haime's monograph. *N. Delucii*, d'Arch., also from Sind, is still more compressed, with a subangular kneel, and much more flexuous septa. *N. subfleuriusianus* also resembles *N. discutus*, Desh., from the Lutetian of the Paris neighbourhood, but it is more inflated in the centre, and its septa are less inflected.

Class: GASTROPODA.

Order: OPISTHOBRANCHIA.

Family: ACTÆONIDÆ d'Orbigny.

Genus: TORNATELLA, Conrad, 1860.

TORNATELLA VREDENBURGI. sp. nov., Pl. 1, figs. 19-20.

Description.—The shell is small, ovoid-conical, ventricose. The spire is short, subconoidal, consisting of five slightly convex whorls whose height is less than half their width: they are separated by deep canal-like sutures, and are ornamented by six broad threads between which there intervene deep spiral grooves of the same width as the threads. With a powerful lens, a few weather-worn traces of very close-set axial lamellæ may be distinguished on the floor of these grooves. The body-whorl is large: it includes four-fifths of the total height. It is regularly oval, not excavated at its base bearing the prolongation of the spiral threads which become bifid towards the anterior extremity. The umbilical slit is almost closed. The mouth is narrow, very tall, oval, anteriorly sinuous (in the type-specimen, a

benk-shaped prominence is simulated, but this is a deceptive appearance due to the specimen being damaged); anteriorly it is much contracted, and posteriorly angular. The outer lip when viewed in side elevation appears convex. The columella is sinuous, with two large, projecting, widely-spaced transverse folds. The columellar margin is detached anteriorly.

Dimensions.

Height	15 mm
Diameter	8.5 "

Occurrence.—Lower part of zone 2 of the Upper Ranikot, amongst the gypseous shales, three miles east of the old coal-pit near Leilan (Fedden, ¹⁹²⁰₁₋₅).

Comparison with other species.—D'Archiac and Haime have not described any Opisthobranchiate mollusca in their monograph on the nummulitic formation of India. They merely mention the Indian occurrence of a shell identified as *Bulla Fortisi*, Brongn., from the Vicentino, which does not occur in the Ranikot collection. Compared with the European eocene species *Tornatella simulata*, Sol., which is very widespread in the Anglo-Parisian basin, *T. Vredenburgi* is distinguished by its having the base more attenuated, the spiral threads closer set, the aperture somewhat more contracted anteriorly, the last whorl but one noticeably shorter. *T. bella*, Conrad, from the Claibornian of Alabama, is more globose than the Indian species, and its spiral grooves are narrower and shallower. Lastly, in *T. parisiensis* from the Thanetian of the neighbourhood of Paris, the dimensions are much smaller, the shape more rounded, and the sculpturing more delicate than that of *T. Vredenburgi*, and of a different character.

Family: *BULLIDE* d'Orbigny.

Genus: *BULLA*, Klein, 1753.

BULLA APICALIS, sp. nov., Pl. I, figs. 14-15.

Description.—Size moderate, shape oval, globular, short and thick; spire involved in an apical funnel at the bottom of which can be seen a very feebly projecting cap-shaped protoconch. Body-whorl posteriorly globose, attenuated anteriorly and at the base; outer lip thin, almost vertical, extruding slightly beyond the apical truncation to which it is attached obliquely. The surface is almost plain but for a few striae of growth disposed without much regularity, curved inward at the base, feebly retrocurrent into the apical funnel.

Dimensions.

Probable height	23 mm.
Diameter	18 "

Occurrence.—Uppermost Ranikot, Jhirak (Vredenburg, ¹⁹²²₁₋₂).

Remarks.—We have little hesitation in referring this fossil to the genus *Bulla* although we have failed to develop the mouth and observe the columella: the apex and the striæ of growth are fairly characteristic of that genus, but the presence of a visible embryonic nucleus at the bottom of the apical funnel is very exceptional. Neither in d'Archiac and Haime's monograph, nor in the fauna of the Paris basin are there any forms allied to this species.

Family: *ACERIDÆ* Pilsbry.

Genus: *ACERA*, Müller, 1776.

ACERA STREPTA, sp. nov., Pl. I, figs. 16-18.

Descriptions.—Small, ovoido-cylindrical, involute. The spire is short, clearly visible, with heterostrophie, scarcely projecting nucleus; it consists of three convex-depressed whorls, separated by a wide and deep canaliculated incision along the suture. Body-whorl very large, constituting almost the whole shell, rounded at the base, covered with fine spiral striations revolving between fairly wide, ribbon-like bifid bands. Mouth very wide, anteriorly expanded; columella sinuous, limited anteriorly by a thin angular margin which continues as a rim round the aperture; inner lip thin, closely fitting to the base, outer lip notched along the sutural channel.

Dimensions.

Height	:	:	:	:	:	:	:	:	:	:	:	:	12 mm.
Diameter	:	:	:	:	:	:	:	:	:	:	:	:	7 "

Occurrence.—Uppermost Ranikot, Jhirak (Vredenburg, $\frac{K 7}{186}$).

Comparison with other species.—This shell is much narrower and rather more ovoid than *A. striatella* from the coeene of the neighbourhood of Paris; it is also distinguished by its spiral ornamentation with bifid ribbons.

Order: PROSOBRANCHIA.

Family: *PLEUROTOMIDÆ* Stoliczka.

Genus: *SURCULA*, H. and A. Adams, 1853.

SURCULA VOYSEYI, d'Archiac and Haime, Pl. I, figs. 25-28.

1850. *Pleurotoma* ind't. d'Archiac, Histoire des progrès de la Géologie, Vol. III, p. 291.

1853. *Pleurotoma Voyseyi*, d'Archiac and Haime, loc. cit., p. 305, Pl. XXIX, fig. 10.

Descriptions.—The size is moderate, the shape biconical. The spire is tall, conical, carrying at its apex a smooth protoconch which consists of one and a half

convolutions. The number of whorls in the spire is seven; they are angular, depressed, their height being equal to one-third of their width. The remarkably elegant ornamentation consists of two delicate granular threads occupying the anterior portion of each whorl, followed by a row of large tubercles whose breadth becomes proportionately greater on the later whorls; beyond these tubercles there is a deeply excavated spiral surface, and lastly a series of small crenulations or of small oblique folds crowded together in the neighbourhood of the suture. The surface also shows sinuous stræ of growth. The body-whorl is large, its vertical dimension being about two-thirds of the total height; its posterior surface carries a ring of blade-like tubercles, behind which is a concave striated spiral surface upon which one observes the successive curved lines of growth of the sinus, which give rise to oblique lamellæ at their junction with the suture. The rounded base caves in slightly towards the neck, and is decorated with granular threads which decrease in size, the nearer they are situated to the anterior extremity; they are decussated by fine oblique lamellæ of growth. The aperture is large, posteriorly angular, ending anteriorly in a long straight canal: the columella is sinuous, the outer lip convex, notched by a deep sinus at its junction with the penultimate whorl. The inner lip forms a thin callosity, closely applied upon the base.

Dimensions.

Probable length	30 mm
Diameter	10 "

Occurrence.—Uppermost Ranikot, Jhirak (Vredenburg, $\frac{K7}{190}$).

Comparison with other species.—All the specimens of this remarkably beautiful shell that we have examined are incomplete, as is also the case with the type figured by d'Archiac and Haime: the long and narrow canal is almost always broken from its very origin, but there is reason to believe that it was not inflected. At any rate, the reference of this fossil to the genus *Surcula* is settled by the position of the sinus in close proximity to the suture. *S. Voyseyi* belongs to the same group of spinose species as *S. dentata* Lamk. from the Lutetian of the Paris region, but differs from it owing to its coarser and much bolder sculpture. D'Archiac and Haime compared the Indian species with *Pleurotomaria Thallavignesi*, Alex. Rouault, from the nummulitic formation of the neighbourhood of Pau. *S. Voyseyi* is distinguished from it by its less elongated habit, the slower rate of increase of its spire, the granular threads on its base, the greater prominence and greater number of its marginal tubercles, the striated and pleated swelling which accompanies the suture, the very fine reticulated striations which cover the sinus-fasciole instead of the rows of granulations which occupy that same position in the species described by Rouault. These differences seem ample for distinguishing the two species, especially from two such distant areas and without any intermediate forms to link them together in the intervening regions, such as Egypt.

SURCULA INDICA, sp. nov., Pl. I, figs. 31, 32.

Description.—The size is moderate, the shape biconical, depressed. The spire is tall, conical, consisting of seven convex whorls whose height is less than half their width, and which are marked off from one another by deep sutures. The anterior portion of each whorl adjacent to the suture constitutes an undulated swelling covered with broad, obsolete axial ribs, which are somewhat irregular and are interrupted at half the height of the whorl, where they are succeeded by a concave spiral fasciole; these ribs are crossed by three or four thick spiral threads, while finer and closer-set threads occupy the concave fasciole.

Dimensions.

Probable length	. . . . .	15 to 16 mm.
Diameter	. . . . .	5 "

Occurrence.—Uppermost Ranikot, Jhirak, (Fedden, ¹²¹₁₂₁).

Comparison with other species.—In spite of the fragmentary nature of this fossil, the canal being completely broken off from its origin, we think it worth describing because its ornamentation and the position of the sinus with reference to the concave fasciole, recall somewhat closely *Surcula textiliosa*, Desh., and some of its varieties, especially *S. Ramondi*, de Boury, from the Bartonian of Paris. Nevertheless, the Indian species must have been more depressed in proportion to its height than *S. Ramondi*, while the ribs on the anterior part of the whorls seem thicker, shorter and less pronounced. *S. indica* does not approach any of the varieties of *S. Voyseyi*, d'A. and H., whose keel is serrated, and whose sinus-band is much more broadly excavated; nevertheless, both species belong to the same natural group, and are at once distinguished from *S. Vredenburgi* and *S. hypermecees* which belong to other sub-generic sections.

Section : *APIOTOMA*, Cossmann, 1889.

SURCULA (*APIOTOMA*) *HYPERMECEES*, sp. nov., Pl. II, figs. 11-13.

Description.—The size is moderate, the shape elongate, fusiform. The spire is tall, slim, conical. Its whorls are slightly convex, posteriorly keeled, and disposed step-wise; their height is equal to two-thirds of their width. Their ornamentation consists, anteriorly of three spiral threads, irregularly interspaced, with a much finer thread in each of the intervening spaces; next comes a well-marked projecting keel, beyond which is situated a narrow concave surface decorated with very fine spiral threads, and lastly a bifid fold covering the suture. The whole surface also carries regular folds of growth whose combination with the spiral ornaments produces an elegant lattice. The body-whorl is large, rounded at the periphery of the base upon which persist the spiral threads and all the lattice ornamentation of the spire; the

raised plications of growth are sinuous on the concave portion of the neck. The aperture is narrow, the outer lip oblique, notched by a deep sinus corresponding with the sinus-band behind the keel. The columella is almost straight posteriorly, scarcely inflected anteriorly relatively to the canal which must have been thin and very long.

Dimensions.

Possible length	27 mm.
Diameter of the same specimen	7 "
Maximum diameter	10 "

Occurrence.—Uppermost Ranikot Jhirak (Fedden, $\frac{121}{121}$ $\frac{240}{a}$, Vredenburg, $\frac{K7}{190}$).

Comparison with other species.—Owing to the more or less incomplete condition of the specimens, the diagnosis can only be established by uniting the characters of a number of fragmentary individuals. This study has established that the canal, though always broken, must have been very long and slender at its extremity, so that the fragments do not enable us to determine the exact ratio between the dimensions of the spire and of the body-whorl. The sinus of the outer lip is situated behind the keel, and quite close to the suture, so that this species evidently belongs to the genus *Surcula* and not to *Pleurotoma*. Owing to the combined characters of its sinus and canal, we are of opinion that *S. hypermees*, notwithstanding the slender shape of its relatively elongated spire, should be classed with the section *Apiotoma*, rather than with *Ancistrostyx* whose sinus is somewhat further removed from the suture; the ornamentation also contributes to confirm this attribution, for it lacks both the basal granulations and serrated crest of *Ancistrostyx*.

Nevertheless, *S. hypermees* is at once distinguished from the other species of *Apiotoma*, and particularly from the sub-generic type *S. pirulata*, Desh., from the lower and middle eocene of the Anglo-Parisian region, by its greater length, the more pronounced step-like disposition of its spire, its more concave sinus-band, and the coarser lattice of its ornamentation. The outline of the shell is slender and elongated instead of piruliform.

Section : *ANCISTROSTYX* Dall, 1881.

SURCULA (ANCISTROSTYX) VREDENBURGI, sp. nov., Pl. I, figs. 29, 30.

Description.—The size is moderate, the shape narrow, biconical. The spire is long, slightly conoidal,¹ terminated by an obtuse protoconch with a smooth terminal cap. There are eight spire whorls which are rather depressed, their height being equal to half their width; they carry two keels, and are separated by deep sutures. At about one quarter of the width measured from the posterior edge, each whorl

¹ Throughout this Memoir, the terms "conoidal" and "extraconic" are used as defined by one of us in a previous publication. [Cossmann, *Essai de Paléontologie comparée*, Fasc. I, (1895), pp. 8, 9.] When the angle of the spire becomes wider on approaching the apex, the spire is said to be "pupiform" or "conoidal". When the angle becomes steeper on approaching the apex, the outline of the spire is said to be "extraconic."

carries a sharp keel followed by a depressed band, then by a second keel as much raised as the first one; this second keel is separated from the following suture by a narrow sloping band. The depressed band and the flat anterior one are absolutely bare of any ornament, the two keels constituting the only sculpture of the spire. The body-whorl is large, its vertical dimension being two-thirds of the total height; in lateral outline it is almost rectilinear; its base is concave, and carries concentric threads regularly distributed, and continued up to the neck which is straight and long. The aperture is narrow, fusiform, terminating anteriorly in a canal which is long, narrow, and not inflected; the outer lip is very oblique, notched between the two keels. The columella is sinuous, the inner lip callous, closely fitting on to the base.

Dimensions.

Length	.	.	.	.	.	.	.	.	.	.	32 mm.
Diameter	.	.	.	.	.	.	.	.	.	.	10 "

Occurrence.—In the lowermost beds, zone 1, of the Upper Ranikot. Two miles east of Kandaira, Vera plain east. (Fedden, ¹⁹²⁰₁₃₁.)

Comparison with other species.—Notwithstanding the complete absence of revolving striations or threads on the anterior region of the whorls, this shell seems to belong to the section *Ancistrostrix* owing to the step-like disposition of its spire, and also on account of its sub-mammillated and scarcely conoidal embryo. In addition to its smooth surface, *S. Fredenburgi* is distinguished from *Ancistrostrix terebrale* Launk., from the lower and middleocene of the Anglo-Parisian region, firstly, by its two keels enclosing the sinus band, secondly, by the strong concentric threads which only commence with the concave portion of the base, lastly and principally, owing to the complete absence of crenulations or serrations on the more anterior of the two keels. If, on the other hand, one seeks points of comparison with *S. pirulata* Desh., type of the section *Apitoloma*, one notices that the Indian shell has a longer spire relatively to the length of the body-whorl, a smooth surface, and the sinus not so close to the suture. It might almost be regarded as intermediate between the two sections *Apitoloma* and *Ancistrostrix*, but we do not dispose of sufficient elements to establish a new subdivision. The relatively low horizon at which it occurs in the Ranikot series harmonises with its somewhat synthetic characters.

Genus: PLEUROTOMA, Lamarek, 1799.

PLEUROTOMA DICTYOPHORA, sp. nov., Pl. IV, figs. 29,30.

Description.—The size is moderate, the shape fusiform. The spire is turretted, regularly conical, consisting of five or six convex whorls whose height is less than half their width, separated by deep canaliculated sutures, ornamented with six thick revolving threads, equal and equidistant; both the foremost and hindmost of these threads are separated from the neighbouring sutures by a narrow band. On

the middle thread, there are obsolete nodes, effaced by weathering, originating from the intersection of small ribs or folds of growth, of very curved shape, scarcely visible on the remainder of the spire. The body-whorl is large, oval, attenuated at its base, somewhat angular posteriorly, with the same ornamentation as the previous whorls, and also with sinuous and arched folds of growth giving the surface a latticed appearance. The aperture is narrow, terminated by a canal which must have been straight and long; the columella is scarcely concave; the columellar margin is narrow, closely fitting to the base, and limited by an incised line; the outer lip is convex in the middle, with sinus distant from the suture, coinciding with the knobs of the last volution.

Dimensions.

Probable height	27 mm
Diameter	10 „

Occurrence.—Uppermost Ranikot, Jhirak (Vredenburg, $\frac{1877}{100}$).

Remarks.—The only Indian species of Pleurotomidæ described by d'Archiac and Haime, *Pleurotoma (Surcula) Voyseyi*, is easily distinguished from *P. dictyophora* owing to the concave fasciole that occurs on the spire whorls, and owing to the swelling that accompanies the suture; its spire also is more elongated. In both species, however, the canal is broken, introducing an element of doubt in their generic attribution. Nevertheless, in the case *P. dictyophora*, the position of the sinus coinciding with the series of nodosities far removed from the suture, renders its reference to *Pleurotoma (sensu stricto)* extremely probable, especially as the canal, judging by its thickness where it is broken off, must have been longer than that of a *Hemipleurotoma*.

Section : *HEMIPLEUROTOMA*, Cossmann, 1889.

PLEUROTOMA (HEMIPLEUROTOMA) EUCALLISTA, sp. nov., Pl. I, fig. 36.

Description.—Small conical, rather narrow; spire pointed at the apex; whorls low, their height being equal to half their width, separated by linear and wavy sutures, almost flat posteriorly, and with a revolving swelling on their anterior region. The elegant ornamentation consists of a small beaded fold at the anterior margin next the suture, followed by slightly oblique knobs with which the thick bulge just mentioned is coarsely serrated; lastly, on the posterior half of the whorls, there are small straight ribs; the latter are more numerous than the knobs and do not in any way coincide with them: there is no definite ratio, such as two to one, as sometimes observed in similar ornaments of other shells. In the interval between the ribs and knobs, there are fine revolving striations. The columella must have been only slightly inflected and the canal rather long.

Dimensions.

Probable length	18 mm.
Diameter	4 „

Occurrence.—Uppermost Ranikot, Jhirak (Vredenburg, $\frac{K7}{100}$).

Remarks.—This small fragment which was found amongst some sorted specimens of *Surcula Voyseyi*, is at once distinguished from that species by the position of its sinus which is situated on the median crenulations showing that the species evidently belongs to the genus *Pleurotoma*, and probably to the section *Hemipleurotoma*. Moreover the ornamentation cannot be compared with that of *S. Voyseyi* though the latter is very variable, for the small straight ribs cover the region that should be occupied by the depressed sinus-band characteristic of *Surcula*; the outline of the shell is also much more slender. We have not hesitated therefore to describe it in spite of the very incomplete condition of the solitary specimen.

Section: *EOPLEUROTOMA*, Cossmann, 1889.

PLEUROTOMA (*EOPLEUROTOMA* ?) *JHIRAKENSIS*, sp. nov., Pl. II, figs. 14, 15.

Description.—Size moderate, shape narrow, biconical; spire elongated, conical, consisting of seven whorls anteriorly convex, posteriorly concave, whose height is equal to half their width, separated by deep sutures, ornamented with broad, oblique ribs, which become bent, or rather displaced where they first meet the depressed zone, and whose terminations constitute upon the suture a small revolving swelling whose serrations do not coincide with the ribs of the previous whorl. This axial ornamentation is everywhere crossed by thin revolving threads which are granular and rather crowded. Body-whorl large, equal in vertical dimensions to about half the total height, deeply hollowed out at the base upon which the axial ribs cease, while the revolving threads become more prominent and further apart. Aperture narrow, ending anteriorly in a thin, prolonged canal, slightly inflected towards the right; sinus situated rather far from the suture, at the point of inflection of the ribs.

Dimensions.

Height	16.0 mm.
Diameter	5.5 „

Occurrence.—Uppermost Ranikot, Jhirak (Vredenburg, $\frac{K7}{100}$).

Comparison with other species.—This species is only represented by more or less fragmentary specimens, but in a state of preservation quite sufficient for determining its characters; it belongs to a group represented in the Anglo-Parisian basin by two Bartonian species, *Pleurotoma lepta* Edw., and *P. contabulata*, Desh., which one of us had at first classified in the section *Oxyacrum* (Cossmann, *Catalogue illustré des*

coquilles fossiles de l'éocène des environs de Paris, IV, (1889), pp. 275, 276), and subsequently in the genus *Drillia*, (*loc. cit.*, App. III (1902), p. 87), which is scarcely more suitable considering the great length of their canal. It will probably be impossible to avoid establishing a special subdivision for these two European species and for the two Indian species *P. jhirakensis* and *P. amphibola* (*vide infra*), but meanwhile, they may be provisionally grouped with *Eopleurotoma*.

P. jhirakensis is at once distinguished from *P. lepta* and even from *P. contabulata* by its thinner ribs, more directly connected with those that form the suprasutural serrations; they do not bifurcate on the last whorl as in the case of *P. lepta*; moreover, the depression which, in *P. contabulata*, intervenes between the ribs and serrations does not occur in the Indian species.

PLEUROTOMA (EOPLEUROTOMA ?) AMPHIBOLA, sp. nov., Pl. I, figs. 33-35.

Description.—Size moderate, shape narrow, biconical; spire elongated, conical, consisting of seven depressed angular whorls whose height is less than half their width, separated by deep sutures, ornamented anteriorly with axial ribs which are broad, widely spaced, tubercular, slightly oblique, whose length is about three quarters the height of each whorl, and which are abruptly interrupted at their posterior extremity by a revolving depressed band followed by a suprasutural fold; the whole surface is traversed by regular revolving threads, finer on the posterior depressed band than on the anterior ribbed portion of the whorls. Body-whorl large, ventricose, excavated at its base upon which the axial ribs disappear, while the spiral threads persist up to the neck of the canal. Aperture narrow, ending anteriorly in a narrow canal slightly inflected towards the right; columella sinuous, feebly callous.

Dimensions.

Probable length	.	.	.	.	.	.	.	.	.	17 mm
Diameter	.	.	.	.	.	.	.	.	.	5 "

Occurrence.—Lower beds of zone 2, three miles east of the old coal-pit near Leilan (Fedden, $\frac{a}{125^{\circ}2}$), and zone 4, Jhirak (Vredenburg, $\frac{K}{19^{\circ}7}$).

Comparison with other species.—*P. amphibola* belongs to the same group as *P. Jhirakensis* so that we may classify it provisionally also with *P. lepta* in the section *Eopleurotoma*; the sinus is situated on the depressed region, immediately behind the terminal swelling of the ribs. *P. amphibola* is specifically distinguished from *P. Jhirakensis* and *P. lepta* by the complete interruption of the ribs on the posterior region of each whorl: there is not even a trace of any serrations answering to the ribs on the swelling contiguous to the suture, as one observes in *P. contabulata*. The great length of the canal which must have been rather slender completely removes all these species from the genus *Drillia* characterised by its short and thick canal and by the callous appearance of the columella.

Genus: DRILLIA, Gray, 1838.

DRILLIA JHIRAKENSIS, sp. nov., Pl. II, figs. 8-10.

Description.—Small, slender; spire elongated, slightly conoidal consisting of eight feebly convex whorls, whose height is equal to half their width, separated by deep sutures, ornamented with thin axial ribs, either quite straight or very slightly inflected, posteriorly interrupted by a groove followed by a crenulated cord overhanging the suture; the remainder of the surface exhibiting traces of thin spiral threads. Body-whorl large, its vertical dimension equal to half the total height, excavated at its base upon which the axial ribs disappear, while a few spiral threads remain visible. Aperture oval, columella excavated.

Dimensions.

Probable length	. . . . .	11.0 mm.
Diameter	. . . . .	3.5 ..

Occurrence.—Uppermost Ranikot, Jhirak (Vredenburg, $\frac{K}{105}^7$).

Comparison with other species.—Amongst the species of the Paris basin, we are not acquainted with any exhibiting the same ornamentation as *D. jhirakensis*; it somewhat recalls that of *D. phlyctiformis*, Cossin, and Pissarro, from the Cotentin, but the shape is quite different. It seems related rather to certain neogene forms, from which it is distinguished nevertheless, by the regularity of its axial ribs persisting up to the suprasutural swelling.

Together with the type, we have figured a variety in which the crenulated swelling that overhangs the posterior suture is somewhat broader, extending to about one-quarter of the height of each whorl; in this variety, the axial ribs of the anterior portion of each whorl end in a slight protuberance against the groove which bounds anteriorly the sutural swelling. Both in this variety and in the type, the canal is broken; yet these shells seem properly to belong to the genus *Drillia*.

DRILLIA ADELA, sp. nov., Pl. I, fig. 37.

Description.—Small, short and thick, biconical; spire short, biconical, spire whorls short, depressed, their height scarcely exceeding one-third of their width, separated by deep sutures, ornamented with thin widely-spaced axial ribs, interrupted by a gap at one-quarter of their length from their posterior extremity; from this gap up to the anterior suture, there is no trace of any spiral ornamentation. Body-whorl very large, its vertical dimension equal to two-thirds of the total height, excavated at its base where the axial ribs cease. Aperture narrow, terminated anteriorly by a canal which was probably short; columella sinuous, slightly callous.

Dimensions.

[illegible]

Occurrence.—Lower beds of zone 2. Three miles east of the old coal-pit near Leilan (Fedden, ¹⁸⁹⁰₁₈₉₂).

Comparison with other species.—This species is very closely related to *Drillia jhirakensis*, and as the type is not in a perfect state of preservation, we should have hesitated to separate it, were it not for its more obtuse shape, and its wider-spaced ribs interrupted posteriorly by a much more obsolete depression; the absence of spiral striations may result merely from the weathering of the surface. The canal is broken just as in the case of the previous species; yet the portion preserved indicates that it must have been short as in the genus *Drillia*; moreover, the ornamentation being of the same type as that of other species of this genus, we think it safe enough to include it amongst them.

Family: *CONIDÆ* Adams.

Genus: *GENOTIA*, H. and A., Adams, 1853.

GENOTIA MURICIFORMIS, sp. nov., Pl. II, fig. 1.

Description.—Large, biconical; spire long, regularly conical in outline: seven spire whorls, angular, depressed, their height being equal to one-third of their width, imbricated and separated by deep sutures. Towards the anterior third and upon the angular portion, the ornamentation consists of a ring of prominent tubercles which are widely-spaced and do not correspond from one whorl to the next one. They are followed by a thick median cord behind which there is a broad excavated band, bounded by a small sutural swelling. Body-whorl large, its vertical dimension being equal to two-thirds of the total height; it is ventricose, slightly excavated at its base which is ornamented with a series of thick concentric threads, persisting up to the anterior portion where a keeled swelling is rolled round the neck. Aperture narrow, anteriorly terminated by a long narrow canal, slightly inflected towards the right; columella smooth, feebly sinuous posteriorly, inflected together with the canal at its anterior extremity; the striæ of growth indicate that the outer lip must have been notched in front of the suture, on the posterior depressed band of the body-whorl. by a broad "pleurotomic" sinuosity.

Dimensions.

Height	.	.	.	.	.	.	.	.	.	.	.	60 mm.
Diameter	.	.	.	.	.	.	.	.	.	.	.	30 ..

Occurrence.—Uppermost Ranikot, Jhirak (Vredenburg, ¹⁸⁷²₁₈₇₃).

Remarks.—The classification of this beautiful shell is particularly puzzling: externally it resembles a *Murex*, or certain kinds of *Melongena*; but it is covered with striæ of growth whose sinuosity indicates that it is certainly a member of the families Pleurotomidæ or Conidæ; moreover, the inflexion of the canal and of the columel

the existence of a swelling on the neck, indicate a real analogy with *Genotia* whose ornamentation somewhat recalls that of the Indian shell. Nevertheless, we are not acquainted with any European shell with which it can be compared. In their memoir on the nummulitic of India, d'Archiac and Haime have figured only one species of *Pleurotomidæ* which does not at all belong to the same group.

Genus : *CRYPTOCONUS*. von Koenen, 1880.

CRYPTOCONUS SURCULÆFORMIS, sp. nov., Pl. II, figs. 6, 7.

Description.—Fairly large, rather slender, biconical; spire elongated, somewhat conoidal, consisting of eight or nine low whorls, their height being equal to about half their width, with flat or slightly convex surface, overlapping for some distance, bearing posteriorly a narrow non-depressed band, separated from one another by deep sutures, and with a tendency to a step-like disposition in full-grown individuals. Surface ornamented with numerous very close-set striae of growth, distributed without much regularity, and traversed anteriorly by an extremely curvilinear sinuosity. Body-whorl large, its vertical dimension being more than half the total height, with a rounded base upon which the lines of growth continue up to the neck of the canal; they exhibit a double sinuosity posteriorly excavated. Aperture narrow, oval, posteriorly angular, terminated anteriorly by a canal, which, judging by the inflection of the striae of growth upon the neck, must have been narrow and short; columella smooth, slightly callous, excavated; outer lip with a very broad crescentic notch in front of the suture which it joins at right angle, very prominent in its anterior portion where it forms another semi-circle before joining the extremity of the columella.

Dimensions.

Probable length	50 mm
Diameter (the mean of two measurements taken from an individual distorted by pressure)	18 "

Occurrence.—In the lowermost beds of the Upper Ranikot two miles east of Kandaira, Vera plain east (Fedden $\frac{6}{11}$), and undercarp of Jakhmari (Noetling, $\frac{K}{638}$).

Comparison with other species.—By its general outline and its almost smooth spire diversified only by a few obsolete threads, this species somewhat resembles a *Surcula*; but if one considers the vast development of the sinus, its anteriorly prominent outline, and especially (judging from the indications furnished by the striations of growth upon the neck), its sinuous junction indicating a relatively short canal, it becomes evident that this shell is a *Cryptoconus*, distinct, however, from other almost smooth species, or from those with only suprasutural lines such as *C. priscus*, Sol., or *C. clavicularis*, Lamk., from the middle and upper eocene of the Anglo-Parisian region. D'Archiac and Haime have not described any fossil of this group.

CRYPTOCONUS PERLIRATUS, sp. nov., Pl. I, fig. 21, and Pl. VII, figs. 47, 48.

Description.—Small, narrow, biconical; spire rather tall, conical or slightly conoidal; spire whorls depressed, their height being a little more than one-third of their width; they are convex and separated by deep sutures with a tendency to a step-like disposition, ornamented with about ten broad, raised, ribbon-like bands, gradually wider-spaced towards the posterior suture. Body-whorl large, its vertical dimension equalling about three-fifths of the total height of the shell; the flat revolving bands persist up to the anterior extremity, and are crossed by very sinuous lines of growth; base excavated at the neck; outer lip thin, deeply notched in front of the suture, and forming a broadly convex curve in front of the sinus.

Dimensions.

Height	.	.	.	.	.	.	.	.	.	.	.	.	20 mm.
Diameter	.	.	.	.	.	.	.	.	.	.	.	.	8 "

Occurrence.—In the uppermost Ranikot beds. Jhirak (Fedden $\frac{9}{12}$); Vredenburg, $\frac{1}{12}$).

Comparison with other species.—The generic determination of this elegant shell gives rise to no hesitation: it has quite the general appearance of the species of the Paris basin, but is essentially distinguished by its regular and persistent ornamentation. Amongst the species of *Cryptoconus* hitherto described, there are very few in which the whorls do not exhibit anteriorly a smooth zone, in front of the sulcated posterior region. In *C. perliratus*, this smooth zone is not developed, at least not up to the size of the figured type: at any rate, the only Parisian fossil whose ornamentation is comparable with that of *C. perliratus*, is the Lutetian species *C. bistriatus*, Desh., whose spiral sulci punctuated and cancellated by the lines of growth do not bear a very close resemblance with the regular ribbons of the Indian species; moreover, the striae of the last whorl in the Lutetian species, are of alternating dimensions—hence the name—while there is nothing of the sort in *C. perliratus*; lastly the height of the aperture relatively to the spire is much less than in *C. bistriatus*.

Amongst completely striated species, one might mention the Lutetian species *C. filiosus*, Lamk., and *C. calophorus*, Desh., which carry pronounced, wide-spaced, spiral grooves, separated by intervals broader than themselves, and therefore very different from the flat or merely incised grooves of *C. perliratus*; moreover, their general outline is much more inflated, and their body-whorl larger. The same remark applies to an oligocene species described by Mayer-Eymar as *Planrotoma Duboisi*.

Genus: *CONUS*, Linnæus, 1758.

CONUS BREVIS, J. de C. Sowerby?, Pl. I, figs. 21, 22.

1840 J. de C. Sowerby, *Trans. Geol. Soc.*, V, Pl. XXVI, fig. 23

1871 D'Archi and Hamme, *loc. cit.*, p. 336, Pl. XXXIV, fig. 6.

Description.—Size moderate, shape conical, rather depressed; spire short, scarcely projecting; protoconch small and button-shaped; four whorls, the last of which

embraces the whole shell whose outline is slightly convex posteriorly, slightly excavated anteriorly.

Dimensions.

[illegible]

Occurrence.—Uppermost Ranikot, Jhirak (Vredenburg, ^{K. 7.} 187).

Remarks.—The geological horizon of the specimen referred by d'Archiac and Haime to J. de C. Sowerby's species is doubtful. Sowerby's type is from the Gaj beds of Kaehh which are not older than uppermost Aquitanian, and which, therefore, differ vastly in age from the Ranikot of Sind. Nevertheless, the Ranikot shell corresponds almost exactly in shape and size with the one figured by d'Archiac and Haime. Our specimen is, however, a mere cast without any trace of external ornaments such as would justify an exact identification. We deem it safest therefore not to attempt any closer determination, especially as d'Archiac and Haime themselves rightly noticed that their specimen might easily be united with the one doubtfully referred by them to *Conus militaris* J. de C. Sow. (another Gaj species), though it appears rather more depressed.

CONUS SUBBREVIS, d'Archiac and Haime?, Pl. I. fig. 23.

1853. ¹ D'Archiac and Haime, *loc. cit.*, p. 336, Pl. XXXIV, fig. 8

D'Archiac and Haimé's description reduces itself to the following sentence: "Very much weathered cast strongly recalling a very short undescribed species from the 'faluns' of Touraine, where it is very common." It is of course impossible to identify our fossil from such a short diagnosis; it resembles, however, the figure published in the "Description," showing a spire slightly taller than that of *C. brevis*. The total height must have been about 35 mm. for a diameter of 15 to 17 mm. The spire whorls were probably angular, so far as can be judged from the incomplete cast which we have figured.

Occurrence.—Uppermost Ranikot, Jhirak (Vredenburg, 185).

Remarks.—As in the case of the previous forms, the exact horizon of d'Archiac and Haime's specimen is not known. According to Fedden (*Mem. G. S.* XVII, p. 210), *C. subbrevis* is also a Gaj species. The authors of the "Description" state that it occurs in a whitish nodular limestone full of quartz grains, a rock quite unlike any of those from the Ranikot, while a material of this description is one of the commonest rocks of the Gaj.

Family . *OLIVELLÆ*, d'Orbigny.

Genus : *ANCILLA*, Lamarck, 1799.

Section : *ALOCOSPIRA*, Cossmann, 1890.

ANCILLA (ALOCOSPIRA) INORNATA, sp. nov., Pl. II, figs. 16, 17.

Description.—Size moderate, shape oval, somewhat short and thick : spire short, conoidal, consisting of four flat whorls, whose height equals half their width, and which are bounded by a channelled depression in the glaze that covers the sutures ; the whorls are anteriorly ornamented with three or four obsolete spiral threads, becoming gradually fainter as they approach the posterior region which is smooth. Body-whorl very large, occupying three-quarters of the total height, with oval base, carrying anteriorly a broad rim posteriorly limited by four threads whose relief decreases as they approach the swelling of the neck which is bounded by an oblique fasciole. Aperture narrow, columella excavated carrying anteriorly five equal oblique folds ; columellar margin callous, very distinct, covering the prolongation of the threads that border the anterior rim.

Dimensions.

Height	23 mm.
Mean diameter measured from an apparently compressed individual	7 ..

Occurrence.—Uppermost Ranikot beds, Jhirak (Fedden, ¹⁹¹¹₁₂₆).

Comparison with other species.—The discovery of an Indian species of *Alocospira* comes rather as a surprise, for it belongs to a subdivision unknown, so far, out of Australasia ; its characters agree strictly with those of the sub-genus, particularly in the threads that ornament the anterior portion of the spire whorls, above the channelled groove that represents the suture. Nevertheless, it is distinguished from the sub-generic type *A. papillata*, Tate, from the Miocene of Australia by its more oval shape, and its shorter, more conoidal spire. *A. sublaevis*, T. Woods, from the Balcombian of Victoria, is much narrower, while *A. Junghuni*, Martin, from the neogene of Java, is much larger, and differently ornamented.

Genus : *OLIVELLA*, Swainson, 1835.

OLIVELLA HOLLANDI, sp. nov., Pl. II, figs. 21, 22 ; Pl. VII, fig. 49.

Description.—Size moderate, shape slender, spire short, extraconical,¹ consisting of four flat tall whorls whose height is equal to half their diameter, and which are separated by deeply channelled sutures. Body-whorl very large, including nearly three-quarters of the total height, oval at its base, bearing anteriorly a narrow

¹ See footnote, page 10

non-enamelled zone bordered by an incised line in front of which is a large flat revolving swelling ; a few threads revolve round the neck. The aperture is narrow, angular, posteriorly notched, anteriorly terminated by a short, broad, notched canal ; columella excavated in the middle, bearing anteriorly two thick oblique folds, behind which is a broad band enclosed between two incised lines, and, posteriorly, two plaits revolving successively ; columellar margin indistinct.

Dimensions.

Height	23.0 mm
Diameter	8.5 "

Occurrence.—Uppermost Ranikot beds. Jhirak (Fedden, $\frac{0.280}{1.240}$).

Comparison with other species.—The species from the Gaj beds of Kachh, *Oliva pupa*, J. de C. Sow., figured by d'Archiac and Haime as occurring also in Sind, is much narrower and less ovally ventricose than *Olivella Hollandi*; besides, if the figure is correct, the folds are disposed quite differently, and it does not even belong to the same sub-genus. Fedden has apparently confounded the Ranikot shell with *Oliva pupa*, for he mentions Sowerby's species both in the Ranikot and Gaj. (*Mem. G. S. I.*, XVII, p. 210). Amongst the species of the Paris basin that seem related to the Jhirak fossil, there is first the lutetian species, *Olivella nitidula*, Desh., which is narrower, and has its suture bordered by a raised fold. *O. micans*, Desh., which occurs at all horizons of theocene, shows somewhat similar columellar folds, but is more ventricose, and has a less extraconical spire; *O. Laumonti* Lamk., another species with a similarly extensive vertical range, has a shorter spire, its sutures are bordered by a swelling, and its dorsal fasciole is less prominent.

OLIVELLA VREDENBURGI, sp. nov., Pl. III, figs. 8, 9.

Description.—Small, short, depressed; spire short, subconoidal; four flat spire whorls, whose height is equal to half their width; they overlap one another, and are separated by deeply channelled sutures. Body-whorl very large, including five-sixths of the total height, with a rounded base bearing anteriorly a rather narrow rim and an oblique swelling upon which there are two or three thick revolving columellar folds.

Dimensions.

[illegible]

Occurrence.—Uppermost Ranikot; Jhirak (Vredenburg, ^{K 7}₁₈₆).

Comparison with other species.—Although this shell is not in a perfect state of preservation, and although the aperture is half-embedded in the matrix, its characters can be made out with sufficient clearness to distinguish it from *O. Hollandi*; its spire is much shorter, conoidal instead of extraconical; the whorls are narrower and

VOLUTOSPINA NORTLINGI, sp. nov., Pl. II, figs. 23, 24.

Description.—Large, depressed; spire short, conical; spire whorls angular, disposed step-wise, ornamented with thin straight axial ribs decussated by grooves that divide them into crenulations; the suture is bordered anteriorly by an isolated crenulated ring, while another series of spiny crenulations terminates the ribs on the angular part of the whorls. Body-whorl large, globose, with thick, slightly spinose ribs, widely spaced and separated by very broad, smooth intervals. Posteriorly these ribs end in a short spine succeeded by a broad declivous band without any other ornamentation than the sutural series of crenulations. Base rounded, with close-set concentric undulating threads. Aperture rather narrow, pyriform; columella sinuous, with a thick anterior oblique fold, beyond which are other finer ones, still more oblique.

Dimensions.

Probable height	.	.	.	.	.	.	.	.	.	56 mm
Diameter	.	.	.	.	.	.	.	.	.	30 "

Occurrence.—Uppermost Ranikot. Jhirak. (Vredenburg, $\frac{h}{17}$).

Comparison with other species.—This interesting shell does not resemble any of the other Ranikot species. Its widely spaced ribs with smooth intervals on the last whorl, at once distinguish it from the previously mentioned group of *V. elevata*. *Voluta siluricensis* described by d'Archiac and Haime from casts obtained in the Punjab, has a much shorter spire without the step-like disposition of the whorls, and its ribs are much more numerous on the body-whorl.

In the Anglo-Parisian basin, *V. depauperata*, Sow., from the Bartonian, is the only form that can be compared with the Indian one, on account of its angular spire whorls, and its widely spaced ribs on the body-whorl; but the European shell usually has spiral grooves, and its ribs are not so prominent or sinuous.

VOLUTOSPINA INTERCRENATA, sp. nov., Pl. II, figs. 18-20; Pl. III, figs. 1-3.

† 1853 *Voluta cf. cylindrica*, d'A and H., *loc. cit.*, p. 325, Pl. XXXII, figs. 4, 5 (non Lamk.).

Description.—Size moderate, shape oval, slightly ventricose; spire short, terraced, regularly conical; five spire whorls separated by deep channelled sutures, ornamented with oblique, rather prominent thick ribs, crossed by two grooves that divide them into rounded, unequal crenulations: the series surrounding the suture is the most prominent, the other is duplicated by a median finer groove. Body-whorl large, occupying a little less than five-sevenths of the total height, oval, somewhat ventricose, declivous at its base which is ornamented with thick axial ribs decussated by striae which become more and more crowded as they approach the anterior portion of the base and the neck; the intervals between the ribs are very elegantly crenulated owing to the intersection of these striae with slightly projecting small costae, numbering two

Dimensions.

[illegible]

Comparison with other species.—This common species is rather variable, especially in its shape. Some of the individuals are relatively much shorter than the above-described specimen; in the thick individual which we have figured to illustrate this variation of shape, the intercalary crenulations that characterise the type, have been obliterated by weathering. *V. intercrenata* cannot be mistaken for *V. Sylkesi* whose ornamentation is very different: instead of the regular crenulations of the latter species, *V. intercrenata* bears thick ribs which are not crenulated by the grooves crossing them; it is only in the intervals between these ribs that the crenulations exist, and they can only be discerned on very freshly preserved specimens. It is also these intercalary crenulations that distinguish it from *V. bicorona*, Lamk. (Intetian of the Paris region), which it otherwise resembles owing to its two circles of suprasutural crenulations, especially that developed round the posterior margin of the body-whorl.

Genus : AULICINA, Rovereto, 1899.

AULICINA HAMEI, d'Archiac, Pl. II, figs. 27-30; Pl. VIII, figs. 2 a, b.

1850. *Voluta Haimi*, d'Archiac, *Histoire des progrès de la Géologie*, Vol. III, p. 298.
1853 D'Archiac and Haimi, *loc. cit.*, p. 325, Pl. XXXI, figs. 20, 27.

Description.—Large, conical; spire very short, feebly prominent, its outline varying according to the age of the individuals; it commences with a very large nucleus constituting a thick flattened knob; the five spire whorls are separated by shallow, finely-incised sutures, and are ornamented with thin concentric threads, somewhat irregularly distributed, and by a circle of obsolete, flexuous tubercles, immediately adjacent to the suture. Body-whorl very large, forming almost the entire shell, ornamented with a ring of big spinose tubercles, separating the posterior flattened region from the base; the latter is regularly conical, and seems bare of ornament. Aperture narrow, with parallel margins; columella rectilinear, bearing at least five folds, of which the two anterior ones are rather oblique, the three following ones quite transverse.

Dimensions.

Height	45 mm.
Diameter	50 "

Occurrence.—Throughout the Upper Ranikot. Zone 1: undersearp of Jakhmari peak (Noetling, $\frac{\kappa}{600}?$); two miles east of Kandaira (Fedden, $\frac{\alpha}{151} \frac{280}{151}$). Zone 2: lower fossiliferous band three miles east of the old coal-pit near Leilan (Fedden, $\frac{\alpha}{126} \frac{280}{126}$). Zone 3: east of Leilan coal-pit (Fedden, $\frac{\alpha}{127} \frac{280}{127}$); north of Leilan coal-pit (Fedden, $\frac{\alpha}{120} \frac{280}{120}$). Zone 4: Jhirak (Fedden, $\frac{\alpha}{121} \frac{280}{121}$; Vredenburg, $\frac{\kappa}{171}?$); left bank of Indus opposite Jhirak (Vredenburg, $\frac{\kappa}{329}?$).

Comparison with other species.—The specimens which we refer to d'Archiac's species are unfortunately incomplete; the spire is perfect in most of them, but the anterior portion of the body-whorl is invariably missing; moreover, the aperture is almost always buried in a very hard matrix from which it cannot be developed. Consequently our diagnosis differs slightly from that published by d'Archiac, and our figures represent much more adult specimens. According to d'Archiac and Haime's description and the figures illustrating it, the whole surface is covered with fine flexuous striations, though, in all our specimens, the intervals between the ribs are smooth on the body-whorl. The columella and parietal region carry eight folds, according to d'Archiac, so that three of them would be concealed in our specimens which is quite conceivable, considering their mode of preservation. Nevertheless, the specimens seem referable to that species. It had already been recognised by Fedden as a characteristic Ranikot species. (*Mem. G. S. I.*, XVII, p. 209.)

The external shape of *V. Haimei* closely resembles that of *Volutoospina strombiformis*, Desh., and *V. athleta* Sol., from the Bartonian of the Paris basin; but evidently these shells do not belong to the same genus as the Indian species, not only on account of the transverse and much more prominent columellar folds of the latter, but especially on account of the large embryonic knob terminating its spire. These characters correspond with those of *Voluta vespertilio* Lin., type of the genus *Vespertilio* Klein (*non* Lin. 1735). The latter name was replaced in 1899 by *Aulicina* Rovereto.¹ Several species of the same genus occur in the Eocene of Australia. Amongst them, *A. Weldi*, Tate (eocene), differs owing to its much more prominent spire, and its ribs persisting on the body-whorl anteriorly to the spines. *A. Johnstoni*, Cossm. (*V. strombiformis*, Johnston, *non* Desh.), also eocene, has quite the same shape, but the columellar folds are fewer. The remaining forms are ribbed and do not resemble *A. Haimei*.

AULICINA PUSIOLA, sp. nov., Pl. II, fig. 34, Pl. III, figs. 4, 5.

Description.—Small, depressed, and exactly conical; spire scarcely projecting, bearing at its summit a big, flattened, obtuse embryonic knob; on the posterior

¹Prime recherche sinon. sur Gen. des Gast., Genou, *Ann. Soc. lig. Sc. nat.*, Vol. X, 1899. Cossmann, *Essais de Paléontologie comparée*, Vol. IV. p. 232 (1901).

surface of the body-whorl which is very large, with rectilinear sides, and constitutes practically the whole shell, there are thin axial ribs, somewhat irregularly distributed, and rather undulating; they do not reach the excavated portion of the neck; they are crossed by spiral grooves, which divide them into small granulations or erenulations, whose size gradually decreases anteriorly. The posterior angular portion of the body-whorl is encircled by tubular tubercles, followed by an excavated region, and lastly, a kind of circular swelling circumscribing the suture of the apical knob. Aperture narrow, with parallel margins, ending anteriorly in a short, broad, truncated canal, somewhat reflected outwards; outer lip thin, almost rectilinear, notched next to the circle of tubercles; columella rectilinear, bearing a series of seven to nine narrow folds, scarcely oblique, almost transverse, especially the posterior ones, rather regularly distributed, the middle ones more prominent.

Dimensions.

Height	15 mm.
Diameter	10 ..

Occurrence.—Uppermost Ranikot, Jhirak (Vredenburg, $\frac{x}{12}, \frac{7}{}$).

Comparison with other species.—This species cannot be mistaken for *A. Haimer* which grows to a large size, while the small specimens of *A. pusiola* which we have studied, seem full-grown; the ornamentation of the body-whorl, and the number and disposition of the columellar folds, are moreover sufficient for distinguishing *A. pusiola* without the slightest hesitation. In the diagnosis, we have been unable to indicate the number of whorls in the almost flat spire; on the best specimen, the surface of this particular portion of the shell has been weathered away, rather giving the impression that the embryonic knob is in immediate contact with the suture of the body-whorl, which would represent a most abnormal development, considering the small size of the full-grown shell; the other specimen figured on account of its well-preserved aperture, is so much weathered upon the dorsal aspect and spire, that it also fails to indicate the number of whorls. There must have been some two or three narrow whorls intervening between the apical knob and body-whorl.

Genus: *VOLUTOCONUS*, Crosse, 1871.

VOLUTOCONUS FUNICULARIS, sp. nov., Pl. III, figs. 10-12.

Description.—Size rather above medium; shape slender, pyriform, spire consisting of nothing but a broad flattened protoconch, with a scarcely convex cap. Body-whorl very large, constituting the entire shell, excavated at its base, rounded or slightly angular posteriorly, ornamented with subgranular threads, which are rather crowded on the flattened band in front of the suture, broader and further apart in the anterior region. There are no axial ribs. Aperture narrow, ending

anteriorly in a thin and feebly produced canal. Columella rectilinear, bearing about ten lamellar folds, first oblique, and then completely transverse on the parietal region. The most anterior fold is less prominent than the next few following ones, their importance regularly decreases from the third onward, the posterior ones being quite obsolete.

Dimensions.

Height	18 mm
Diameter	10 "

Occurrence.—Uppermost Ranikot, Jhirak (Vredenburg, $\frac{x}{12}$).

Comparison with other species.—Although represented by poorly preserved specimens, this species is very interesting; like the above-described *Aulicina*, it belongs to a genus which is not represented in Europe. It is in the Australian Eocene that we have to seek our terms of comparison. *V. funiculifer* resembles the Australian *V. conoideus*, Tate, but is distinguished by its spiral ornamentation and columellar folds. There is nothing in d'Archiac and Haime's Memoir that can be identified with *V. funiculifer*; the form most nearly resembling it is *Aulicina Haimei*, which has almost the same shape, the same folds, and the same spiral ornamentation, but which grows to a very large size, when it assumes a strombiform shape quite unrelated to *Volutoconus*; moreover, even in young shells, the spire, especially round the body-whorl, is encircled by a row of spiny nodules, of which there is no trace on the posterior obsolete angle of the body-whorl of *V. funiculifer*. As to *Aulicina Sismondai*, d'Arch., it is narrower, with a hemispherical embryonic cap, and sinuous lines of growth on the posterior suprasutural band.

VOLUTOCONUS? CORRUGATUS, sp. nov., Pl. III, figs. 6, 7.

Description.—Size moderate, shape oval; spire short, consisting of nothing but the protoconch, which constitutes a large prominent knob, with oblique, non-seaphelloid nucleus. Body-whorl very large, constituting three-quarters of the total height, oval, posteriorly rounded, ornamented with very sinuous axial ribs, with a broad sinuosity towards the posterior suture, traversed by very close-set spiral threads which divide them into imbricated crenulations. Aperture rather narrow, as tall as the last whorl; columella excavated in the middle, bearing anteriorly four lamellar folds, of gradually decreasing thickness.

Dimensions.

Height	21 mm.
Diameter	12 "

Occurrence.—Uppermost Ranikot, Jhirak (Vredenburg, $\frac{x}{170}$).

Comparison with other species.—The ornamentation of this species completely separates it from the one previously described; moreover, judging by the striations of growth, the outer lip must have exhibited a sinuous notch, making it somewhat uncertain whether the shell is really a *Volutaconus*; unfortunately the aperture is incomplete, so that the generic attribution is necessarily only provisional.

Genus: *LYRIA*, Gray, 1847.

LYRIA SIHURIENSIS, d'Archiac and Haime, Pl. III, figs. 25, 26.

1853. *Voluta sihuriensis*, d'A. and H. *loc. cit.*, p. 327, Pl. XXXII, fig. 7 (non Pl. XXXIII, fig. 12)

Description.—Medium-sized, thick-shaped; spire short, conical, terminated by a smooth, globular protoconch, with hemispherical cap; four spire whorls, rather depressed, slightly convex, terraced, separated by deeply channelled sutures, ornamented with thick, oblique, widely-spaced, axial ribs, prolonged beyond the posterior portion of each whorl in the form of a series of nodose crenulations, encircling the channelled sutural band; these ribs do not exactly correspond from whorl to whorl. Body-whorl large, constituting three-fifths or a little more of the total height, ventricose, excavated at its base upon which the axial ribs become attenuated before reaching the anterior region which bears imbricated revolving striae disappearing on the posterior portion of the body-whorl; columella with a series of short folds, equal and close-set.

Dimensions.

Height	21 mm.
Diameter	12 „

Occurrence.—Uppermost Ranikot, Jhirak (Vredenburg, $\frac{1}{174}$).

Comparison with other species.—D'Archiac and Haime's description is illustrated by two figures representing evidently separate species and it is the first one only that fairly closely answers to the Jhirak specimens which we have figured; moreover, d'Archiac and Haime's types are casts, so that these authors make no mention of the spiral striations that characterise our specimens. We have referred them to the genus *Lyria*, although we have succeeded in developing the columella only upon one of the figured specimens; but in fig. 7 of d'Archiac and Haime's work, columellar folds such as characterise the genus *Lyria* are fairly well shown, and are also mentioned in their diagnosis, which further confirms its relationship to our specimens.

Lyria sihuriensis differs from *L. harpula*, Lamk. (lower and middle cocene of the Paris region), by the stronger crenulations of its ribs in front the sutural shoulder, and also by its basal striations; the step-like disposition of its spire is more pronounced, and its length greater. The obliquity and sinuosity of its ribs recall *L. Coroni*, Morlet (middle and upper cocene), of the Paris basin, but the spire is much longer.

Family: *MITRIDÆ*.Genus: *MITRA*, Lamarek, 1799.Section: *CANCILLA*, Swainson, 1840.*MITRA (CANCILLA) BRACHYSPIRA*, sp. nov., Pl. III, figs. 31. 32.

Description.—Small, buccinoid; spire rather short, conical; protoconch smooth, globular, consisting of one and a half whorls. The spire consists of five feebly convex whorls whose height is equal to half their width, separated by deep sutures, ornamented with six deeply incised spiral grooves, and with slightly sinuous or oblique axial grooves of equal depth, dividing the whole surface into a series of well-marked small rectangles. Body-whorl very large, constituting more than two-thirds of the total height, rounded at its base upon which the ornamentation persists up to the anterior margin. Aperture oval, narrow, posteriorly channelled, ending anteriorly in a short, broad canal; columella feebly excavated in the middle, bearing a series of five or six close-set folds, feebly prominent, and slightly oblique.

Dimensions.

Probable height	.	.	.	.	.	.	.	.	.	12 to 15 mm
Diameter	.	.	.	.	.	.	.	.	.	5 5 „

Occurrence.—Upper Ranikot, lower fossiliferous band in zone 2, three miles east of the old coal-pit near Leilan. (Fedden, $\frac{6}{12} \frac{20}{24}$.)

Comparison with other species.—Although the type-specimen has the aperture damaged, so that one cannot ascertain whether the canal was short or slightly elongated, straight or twisted, it appears to us, judging by the ornamentation of the spire and the columellar plication, that this fossil belongs to the section *Cancilla* of the genus *Mitra*, of which two species have been described from the Eocene of the United States. The Indian species differs from them by its relatively short spire, and the regularly crenulated plaits that cover its whole surface.

Family: *FUSIDÆ* d'Orbigny.Genus: *FUSUS*, Lamarek, 1801.*FUSUS? JHIRAKENSIS*, sp. nov., Pl. III, figs. 17, 18.

Description.—Size moderate; shape narrow and fusiform; spire long, regularly conical; spire-whorls numerous, depressed, their height being less than half their width, very convex, separated by deep sutures surrounded by a small ridge, ornamented with straight, prominent, thick, widely-spaced ribs, corresponding fairly regularly from one whorl to the next one, in consequence of which the spire assumes a rather

pyramidal shape; the ribs are crossed by five prominent thin, non-bifid threads, the two hindmost of which are closer together than the three others. Body-whorl large, including about half the total height, excavated at its base upon which the ornamentation persists up to its anterior portion. Aperture semi-circular; outer lip externally thickened by the last rib; columella excavated, adjacent to a canal which was probably long and straight.

Dimensions.

Probable height	.	.	.	.	.	.	.	.	.	.	25 mm.
Diameter	.	.	.	.	.	.	.	.	.	.	15 "

Occurrence.—Uppermost Ranikot, Jhirak (Vredenburg, $\frac{K}{183}$).

Remarks.—As all the specimens have the canal broken, it is not possible to decide whether this shell belongs to the genus *Fusus*, *sensu stricto*; the columella was perhaps not entirely smooth, and the unknown extremity of the canal may have been inflected, so that the shell might perhaps belong to the genus *Lathyrus*, as suggested by its coarse ornamentation and polygonal ribs, rather than to the genus *Fusus* where the revolving ornamentation usually predominates. Nevertheless, the state of preservation of the specimens is quite sufficient at least for a specific determination, and they do not resemble any of the Fusidae figured by d'Archiac and Haime in their work on the Nummulitic of India.

Section: *PAGODULA*, Monterosato, 1884.

FUSUS (*PAGODULA*) *COLOPHORUS*, sp. nov., Pl. III, figs. 27, 28; Pl. VII, fig. 50.

Description.—Size moderate, shape fusiform; spire moderately elongated, regularly conical, consisting of five slightly convex whorls whose height is less than half their width, separated by sutures which are either channelled or step-like; the whorls are ornamented with straight axial ribs, compressed, lamellar, coinciding almost exactly from whorl to whorl. Body-whorl very large, including rather more than two-thirds of the total height, excavated at its base upon which the axial ornamentation persists up to the base of the canal which also carries a few concentric furrows becoming gradually closer together anteriorly. Aperture narrow, pyriform, anteriorly terminated by a long, narrow, straight canal; columella excavated in its posterior region, apparently smooth; columellar margin callous, closely adhering to the base.

Dimensions.

Height	.	.	.	.	.	.	.	.	.	.	15 mm.
Diameter	.	.	.	.	.	.	.	.	.	.	7 "

Occurrence.—Uppermost Ranikot, Jhirak (Vredenburg).

Remarks.—The generic affinities of this shell are decidedly puzzling: its axial folds recall certain forms of *Mitrella*, but the columella is smooth, and the canal long and rectilinear. Most of the species of *Trochus* with axial folds reaching the neck of

the canal, as they also do in *Fusus colpophorus*, have an inflected canal and a basal ridge upon which are folded the axial lamellæ, and differ in these respects from *Fusus colpophorus*. Unless we create a new sub-division, which would be unsafe, considering the poor state of preservation of these fossils, we are driven to refer it to the sub-genus *Pagodula* Monterosato, characterised by a straight canal upon which persist the axial folds, without there being any basal ridge. It is true that the sub-generic type of *Pagodula*, the Mediterranean species *Murex vaginatus*, Jan., occurring also as a fossil in the Pliocene of Italy, has angular whorls, the axial ribs carrying spines at their intersection with the revolving angle; but one of us has already classified in this same group, a lower coeene species of the United States. *Murex morulus*, Conrad, which had erroneously been grouped with *Trophon*, and is not spinose.¹ This would tend to show that the sub-genus *Pagodula* originated with ribbed forms, and did not reach the spinose stage until the Miocene period.

Genus: STREPTOCHETUS, Cossmann, 1889.

STREPTOCHETUS? Pl. III. figs. 19, 20.

Description.—Size moderate, shape narrow, fusiform; spire long, conical; whorls low, imbricated, their height equal to about one-third of their width, separated by deep undulating sutures encircled by a ridge; the whorls are ornamented with thick tubercular axial ribs, not reaching the posterior suture, coinciding almost exactly from whorl to whorl, crossed by ten to twelve equal and regular prominent threads, which are sometimes bifid, and are much narrower than the intervals between them; in addition to these, the entire surface carries the traces of fine and crowded lines of growth. Body-whorl very large, excavated at its base upon which the ornamentation persists up to its anterior portion; outer lip externally thickened by the last rib; columella and canal truncated by a fracture.

Dimensions.

Probable height	.	.	.	.	.	.	.	.	.	25 mm.
Diameter	.	.	.	.	.	.	.	.	.	10 "

Occurrence.—Upper Ranikot, lower fossiliferous band in zone 2, three miles east of the old coal-pit near Lcilan (Fedden, $\frac{a}{1.0^{\frac{250}{a}}}$).

Remarks.—It is only from its general appearance, and the ornamentation of its nodular ribs, that we presume this fossil to be a *Streptochetus*; the canal is broken off almost at its origin, so that we cannot ascertain whether it possessed the anterior inflection, and whether the neck carries the ridge that characterises the genus; the columella, too, is embedded in the matrix, so that we do not know whether it is smooth. Owing to these uncertainties, we have thought it better not to give a specific name to this shell which, apparently, was not known to d'Archiac and Haime. Amongst the species of the Paris basin, it somewhat resembles *S. incertus*, Desh. (Lutetian), though its suprasutural ridge is much more conspicuous.

¹ Cossmann, *Essais de Paléconchologie comparée*, V, p. 192, (1903).

Family: *STREPTURIDÆ* Cossmann.

Genus: *STREPSIDURA*, Swainson, 1840.

STREPSIDURA INDICA, sp. nov., Pl. III, figs. 33, 34.

Description.—Size moderate, shape depressed; spire short, extraconical, with pointed apex terminated by a smooth protocone of one whorl and half; the spire consists of five convex, depressed whorls, whose height is scarcely more than one-third of their width, separated by deep sutures surrounded by a double crenulated ridge. The whorls are ornamented with thin curvilinear ribs, traversed by five spiral threads gradually decreasing as they recede from the anterior suture, combining with the ribs to form an elegant lattice, further decussated with fine lamellæ of growth. Body-whorl large, globose, occupying about four-fifths of the total height, rounded at its base upon which the ornamentation persists as far as the neck which is excavated and separated from the base by a keel. In front of this keel is a prominent ridge carrying hooks formed by the successive growths of the notch. Aperture large, oval, anteriorly terminated by a broad canal, strongly deflected to the right, with a deep notch at the neck; columella sinuous, excavated in the middle, deflected anteriorly together with the canal, with a thick, very prominent fold at the point of inflection; columellar margin thin, closely fitting to the base.

Dimensions.

Height	20 mm.
Diameter	15 „

Occurrence.—Uppermost Ranikot beds, Jhirak (Fedden, $\frac{a}{124}$; Vredenburg, $\frac{K7}{178}$).

Comparison with other species.—This interesting species is much more delicately ornamented than the eocene *S. turgida*, Sol., of the Anglo-Parisian basin, from which it is further distinguished by the more spherical shape of its body-whorl, notwithstanding that its spire is more acute; it has not either the terraced, subspinose whorls of the above species, nor of *S. brevispira*, Cossm., from the eocene of the Loire-Inférieure whose canal, moreover, is much more elongated. Equally marked differences separate it from the oligocene species, such as *S. arcuata*, Sow., *S. semicostata*, Edw., *S. Bolli* Beyrich. It is interesting to find this genus represented in the eocene beds of Southern Asia, though it has never yet been noticed in Egypt or in Australia, and the family Strepturidæ is represented in America by the single genus *Whitneya*, Gabb.

Family: *FASCIOLARIIDÆ* Chenu.

Genus: *LATHYRUS*, Montfort, 1810.

LATHYRUS? Pl. III, figs. 15, 16.

Description.—Size moderate, shape narrow, fusiform; spire long, regularly conical; spire whorls tall, their height being equal to half their width, convex, separated by

deep sutures, ornamented with thick, oblique, wide-spaced, axial ribs, which do not coincide from whorl to whorl; these ribs are crossed by five spiral threads which are prominent, regular, the posterior one bifid; intermediate finer threads, not easy to detect, are intercalated amongst them. Body-whorl large, apparently constituting two-thirds of the total height, with rounded base upon which the ornamentation persists up to the anterior region. Aperture narrow, probably with a rather long canal; outer lip thin, lacinated by the spiral threads; columella sinuous, excavated in the middle, apparently without folds; columellar margin callous, slightly dehiscent anteriorly.

Dimensions.

Probable height	.	.	.	.	.	.	.	.	.	35 mm.
Diameter	.	.	.	.	.	.	.	.	.	11 "

Occurrence.—Upper Ranikot, higher fossiliferous band of zone 2, three miles east of the old coal-pit near Lelan; Bandh Vera plain east (Fedden, $\frac{a \approx 20}{150}$).

Remarks.—The canal of this shell being broken off just at the height where the deflection towards the right takes place in *Lathyrus*, it is impossible to determine exactly its genus. Its ornamentation is that of a *Lathyrus*, but there are no folds visible on the part of the columella which is preserved. Therefore, until better material is available, we merely mention its presence without giving it any specific name. The illustrations in d'Archiac and Haime's *Memoir on the Nummulite of India* do not contain anything similar, and the Egyptian fauna does not appear, so far, to contain any species related to it.

Family: *BUCCINIDÆ* Troschel.

Genus: *LEVIBUCCINUM*, Conrad, 1865.

Section: *EURYOCHETUS*, Cossmann, 1896.

EURYOCHETUS NASSEIFORMIS, sp. nov., Pl. III, figs. 21, 22.

Description.—Size moderate, shape ovoid-conical, buccinoid; spire elongated, regularly conical, terminated by a smooth protoconch of one convolution and a half; the spire consists of six convex whorls whose height is equal to half their width, separated by deeply-channelled sutures, ornamented with thick, oblique, regular ribs, somewhat attenuated anteriorly, crossed by a dozen threads of the same width as the intervals between them, regularly spaced, slightly closer together at the posterior margin of the whorls. Body-whorl very large, occupying two-thirds of the total height, with rounded base upon which the axial ribs disappear, while the revolving threads persist up to the neck which bears an obsolete ridge. Aperture large, oval, anteriorly terminated by a short, broadly notched canal; columella smooth, very much excavated, anteriorly deflected near the notch; outer lip thin, slightly sinuous posteriorly, internally smooth, columellar margin callous, closely fitting to the base separated from the basal swelling by an imperforate incision.

Dimensions.

Height	21 mm.
Diameter	10 „

Occurrence.—Uppermost Ranikot beds, Jhirak (Fedden, ^{n 240}/₁₂₁₅, Vredenburg, ^{K. 7}/₁₈₂)

Comparison with other species—Though the type of the sub-genus *Euryochetus* (genus *Levibuccinum*) is a shell without ribs, this is the only group amongst the Buccinidae whose aperture exhibits any analogy with the Jhirak shell. The columella is perhaps a little more deflected than in the lower eocene *E. cylindraceus* Desh., but its anterior termination is similar; moreover, the outer lip is slightly sinuous posteriorly and internally smooth, just as in the Parisian species. Possibly *E. nassaformis* may eventually be separated as the type of a distinct section in consequence of its more slender shape and *Nassa*-like ornamentation, but it must remain closely connected with *Euryochetus* on account of the relationship indicated by the aperture. D'Archiac and Haime have described a certain number of Buccinoid species belonging to various genera, but none of them agree with *E. nassaformis*

Family: *TRITONIDÆ* Broderip.

Genus: *EUTRITONIUM*,¹ Cossmann, 1904.

Section: *SASSIA*, Bellardi, 1871.

EUTRITONIUM (SASSIA) *SINDHENSE*, sp. nov., Pl. III, figs. 29, 30.

Description.—Small, narrow, slender, fusiform; spire elongated, conical; protoconch smooth, globular, of one and a half volutions; five very convex spire-whorls whose height is equal to half their width, separated by deep sutures, ornamented with curvilinear axial ribs, close-set, coinciding in successive whorls, crossed by four regular revolving threads in the intervals between which is a smaller intercalary thread, forming small nodosities at their intersection with the axial ribs; each whorl carries, in addition, one projecting varix. Body-whorl large, occupying a little more than half the total height, rounded at its base upon which the ornamentation persists as far as the excavated neck; a rather prominent varix exists on the side opposed to the outer lip, at about 120° from the ventral surface. Aperture large, oval, without a posterior channel, anteriorly terminated by a narrow, elongated canal, a small portion of which has unfortunately been accidentally broken off on the type-specimen; outer lip with a thick external rib, and, internally, five or six equidistant teeth; columella excavated, feebly bent; columellar margin callous, detached from the base and from the neck.

Dimensions.

Height	12 to 13 mm.
Diameter	7 „

¹ The generic name *Eutritonium*, Cossmann (April 1904) has priority on *Septa* (Perry), Dall. (August 1904)

Occurrence.—Upper Ranikot, lower fossiliferous band in zone 2, three miles east of the old coal-pit near Leilan (Fedden, $\frac{9}{1.6} \frac{2.0}{a}$).

Comparison with other species.—D'Archæ and Haime's Memoir, in addition to two *Ranellæ* with varices diametrically opposed to the outer lip, contains but one species of the same genus, *Triton Davidsoni* (Nari and Gaj according to Fedden) which does not seem related to the shell above described, as it is shorter, more conical, with a less elongated canal. *E. sindiense*, like most of the species of the Paris basin, belongs to the sub-genus *Sassia*: it is narrower than *E. Dumortieri*, Baudon (Lutetian); its ornamentation differs from that of *E. Lejcunei*, Melleville (lower eocene), being more regular, and less granose. It is more distinctly cancellated than the narrow shaped *E. colubrinum*, Lamk. (Lutetian).

EUTRITONIUM (SASSIA) PERMUTABILE, sp. nov., Pl. III, figs. 37-39.

Description.—Size moderate, shape fusiform, varying according to the age of the shell; spire rather elongated, conical, consisting of eight whorls, first convex, then angular, whose height is equal to about half their width, separated by very deep sutures, ornamented anteriorly with three rather widely-spaced spiral cords, and three others situated closer together on the posterior band behind the angular portion of the whorls; they are crossed by small curvilinear, axial ribs, at wider intervals than the revolving threads, so that the meshes formed by their intersection are oblong; conspicuous varices, thin and prominent, occur here and there on each whorl. Body-whorl very angular, with wider-spaced axial ribs, giving rise to sharp, sub-spinose nodosities where they meet the posterior angle; the base is rapidly attenuated, excavated behind the neck. Aperture oval, relatively small, with a feeble posterior channel, anteriorly terminated by a rather long narrow canal, bent at the neck; outer lip vertical, externally bordered, at some distance from its margin, by a very prominent, rather spinose varix; the margin is crenulated by the extremities of the revolving threads; at about one quarter of the length of the outer lip, measured from the suture, is a small notch, almost reaching the varix.

Dimensions.

Probable length	.	.	.	.	.	.	.	.	.	.	25 mm.
Diameter	.	.	.	.	.	.	.	.	.	.	25 „

Occurrence.—Uppermost Ranikot, Jhirak (Vredenburg, $\frac{K7}{100}$).

Relations to other species.—This species differs greatly from *E. sindiense* not only by its ornamentation, but also on account of its shorter spire and angular whorls; the siphonal canal is rather more deflected, and the outer lip bears a small notch like that observed upon certain kinds of *Sassia*, but wanting in *E. sindiense*. Amongst the Parisian species, it may be compared with *E. goniatum* Cossm., from the Lutetian of Chaussy, which also has angular whorls, but with less spinose projections on the last one; the varices of the Indian species are also more prominent, resembling a knotted

rope. In general appearance, *E. permutabile* is especially distinguished by the manner in which the whorls alter with the growth of the shell, the later ones becoming quite different from the earlier ones.

Genus: RANULARIA, Schumacher, 1817.

RANULARIA? Pl. III, figs. 35, 36.

Description.—Size moderate, shape pyriform; spire short, consisting of four or five low, convex whorls, separated by deeply channelled sutures, ornamented with five or six spiral threads, equal and equidistant, narrower than the intervals between them, crossed by obsolete, curvilinear, axial ribs which form small nodosities at their intersections; each whorl also carries a thick varix, ventrally situated. Body-whorl large, globose, with rounded base upon which the ornamentation persists, with a varix at about 110° from the outer lip; the outer lip is externally thickened by a large swelling; columellar margin wide, callous, fitting closely to the base, traces of the ornamentation of the body-whorl, being distinguishable through it by transparency.

Dimensions.

Promble height	23 mm.
Diameter	16 "

Occurrence.—Uppermost Ranikot, Jhirak (Vredenburg, $\frac{K7}{161}$).

Remarks.—Although the canal is damaged and truncated at the level of the base, this shell appears to belong to the genus *Ranularia*, of which *Triton piraster*, Lamk., is an eocene representative. The present shell, however, is distinguished by a much finer and much more regular ornamentation.

On account of the totally missing canal and concealed columella, we have refrained from naming this form specifically.

Family: CASSIDIDÆ Herrmannsen.

Genus: SEMIOASSIS (Klein. 1753), Mörch 1852.

SEMIOASSIS PHILLIPSI, d'Archiac and Haimo, Pl. III, figs. 42-44.

1850. *Cassio*, indet., d'Archiac, *Histoire des progrès de la Géologie*, Vol. III, p. 295.

1853. *Cuvier Phillipsi*, d'Archiac and Haimo, *loc. cit.*, p. 318, Pl. XXXI, fig. 5.

Description.—Rather large, short, approximately spherical, globose, buccinoid; spire very short though the apex is prominent, conical or somewhat extraconic, non-varicose; six narrow spire-whorls whose height is scarcely one-quarter of their width, very slightly convex, anteriorly subangular, separated by deep-channelled sutures, bordered anteriorly by a thread limited by a revolving groove; the remainder of the surface bears no other ornamentation but very oblique and rather regular striae of growth. Body-whorl very large, including six-sevenths of the total height, laterally

rounded, sub-angular posteriorly, ornamented, like the preceding whorls, with crowded, curvilinear lines of growth which abut at right angles against the suture; the base, which is excavated, bears a few small concentric threads as far as the keeled ridge accompanying the neck of the canal. Aperture large, semi-elliptical, anteriorly terminated by a rather broad canal which is deflected towards the right, apparently notched, its successive growths being indicated on the neck by very crowded hooks; outer lip rather sinuous and excavated in the middle, not projecting anteriorly; columella feebly deflected, with one thick, simple oblique fold, separated by a deep depression from a very thick median swelling carrying four or five transverse wrinkles; columellar margin constituting a bulky callus spreading over one-half of the body-whorl, becoming narrower at the anterior extremity where it coats the base and part of the neck, and obliterates the umbilicus.

Dimensions.

Height	48 mm
Diameter	35 ..

Occurrence.—Lowest zone of the Upper Ranikot, two miles east of Kandaira, Vern plain east (Fedden, ¹⁸⁹⁰₁₃₁).

Relation to other species.—This beautiful shell which is in rather a fine state of preservation, lacks the varices which characterise the genus *Cassis*, while its columellar swelling is more prominent than is usually the case with *Semicassis*. Nevertheless, it seems unquestionably to belong to the latter genus, and, in particular, to the smooth-shelled group of *S. saburon*, Linn. It is distinguished from the latter neogene and recent species by its more projecting spire and more angular whorls, the body-whorl appearing especially angular when not quite full-grown; moreover, the median swelling of the columella is better marked by the marginal callus in *S. saburon* than in *S. Philippii* whose callus is tumid and more closely applied to the base.

D'Archiaie and Haime have described a very fragmentary cast of *Semicassis* from Sind, under the name of *Cassis sublaevigaster*; its spire seems longer and more conoidal than that of the casts of *S. Philippii*; the latter is the one that really agrees with the specimens from the neighbourhood of Kandaira above described, rather than the other, supposing that it is really distinct. As to the undetermined fragments of *Cassis* figured by d'Archiaie and Haime (Pl. XXXI, figs. 7, 8), it is not certain whether they belong to the same genus, in spite of the longitudinal folds exhibited by the cast, because the canal seems to be deflected outwards, and the neck more elongated than in *Semicassis Philippii*.

Genus *CASSIDEA*, Swainson, 1840.

Section: *CASMARIA*, H. and A. Adams, 1853.

CASSIDEA (CASMARIA) GRADIFERA, sp. nov., Pl. VI. figs. 8-10.

Description.—Small, short, globose; spire feebly prominent, forming successive steps, approximately conical in general outline; four convex spire-whorls separated

Dimensions.

Height **29 mm.**

Diameter **10 „**

Comparison with other species.—The characters of this shell almost exactly agree with the generic diagnosis of *Casmaria*, a subgenus of *Cassidea*, which is characterised principally by the keel bordering the neck, and the feeble development of the columellar margin. In both these characters it is closely related to *C. Muellerei*, Tate, from the Miocene of Victoria in Australia,¹ which also has its spire disposed in successive steps, but is differentiated by its larger aperture, its less spherical body-whorl, and the much shallower notch at its neck.

Genus : CASSIDARIA,² Lamarck, 1812.

CASSIDARIA ARONIACI, sp. nov., Pl. IV, figs. 8-10.

1853 *Ossidaria* cl. *carinata*, Lamk., in d'A. and H., loc. cit., p. 317, Pl. XXXI, fig. 1.

Description.—Size moderate, shape buccinoid; spire rather elongated, acuminate, extraconical, with a smooth protoconch with obtuse nucleus; the spire consists of five whorls which are at first convex, biangular, depressed, separated by deeply channelled sutures bordered by a projecting ridge; the whorls are ornamented with two granular keels, one of which is quite close to the anterior suture, the other situated further back, in front of the revolving band that extends up to the posterior sutural rim; the entire surface is covered with thin revolving threads of alternating size, crossed by exceedingly crowded fine striæ of growth, visible only with a strong lens. Body-whorl large, with two lateral angular swellings situated at some distance above one another, and bearing two equal circles of tubercles; the alternating

¹ Cossmann, *Essai de Paléoconchologie comparée* V, p. 128, Pl. V, fig. 16 (1903).

² The validity of the generic name, *Coaxidarius* Lammk., in preference to *Morio*, Mntf., has been discussed in detail by one of us. (Cossmann, *Essai de Paléontochologie comparée*, V, p. 130)

revolving threads of the spire persist all over the body-whorl, and become more crowded on the base. Aperture oval; outer lip oblique, limited externally by a thick swelling; columellar margin callous, sub-detached anteriorly; there is a thick varix on the ventral surface of the last whorl.

Dimensions.

Probable height	.	.	.	.	.	.	.	.	.	28 mm.
Diameter	.	.	.	.	.	.	.	.	.	18 ..

Occurrence.—Uppermost Ranikot, Jhirak (Fedden, $\frac{n}{121} \frac{290}{2}$; Vredenburg, $\frac{K}{182} \frac{7}{2}$); left bank of Indus opposite Jhirak (Vredenburg, $\frac{K}{308} \frac{7}{2}$).

Comparison with other species.—Of the two species referred by d'Archiac and Haime to the genus *Cassidaria*, this is the one which they doubtfully identified with *C. carinata*, Lamk. (*C. nodosa*, Sol.) of the "Calcaire Grossier" near Paris. It differs from the Parisian species by having only two equal rows of tubercles instead of five gradually decreasing ones; its tubercles are also more spinose, and the spiral striations much finer. The lower coeque *C. diadema* Desh. is much more ventricose than the Indian species, and its three tuberculated keels do not correspond with the two rows of crowded, spinose knobs of the Indian species. The other species described by d'Archiac and Haime, *C. Desori* is without tubercles, its spire is disposed in steps and is taller than that of *C. Archiaci*, and, judging from the figure, the revolving striæ that intervene between the five principal spiral threads of *C. Desori*, are neither so fine nor so crowded as in *C. Archiaci*.

Family: *DOLIIDÆ* H. and A. Adams.

Genus: *PIRULA*, Lamarek, 1799.

PIRULA? Pl. III, figs. 40, 41.

Description.—Small, oval, pyriform; spire short, conoidal, consisting of a few very convex whorls whose height is slightly less than half their width, separated by deep channelled sutures; their ornamentation consists of about ten regular thin spiral threads, much narrower than the intervals between them, crossed by thin, oblique plications of growth, whose intersection produces an elegant lattice of rectangular meshes. Body-whorl very large, with rounded base upon which the ornamentation persists. Aperture wide, oval; columella excavated in the middle; columellar margin concealed; the siphonal canal seems to have been long and inflected.

Dimensions.

Probable height	.	.	.	.	.	.	.	.	.	20 to 25 mm.
Diameter	.	.	.	.	.	.	.	.	.	9 ..

Occurrence.—Lowest beds of Upper Ranikot, undersearp of Jakhmari peak, Laki range (Noetting, $\frac{K}{667} \frac{7}{2}$).

Family: *CYPRÆIDÆ* Gray.

Section : *Eoerythra*. Cossmann, 1903.

1850. *Orula incompleta*, d'Archiac, *Hist. des progrès de la Géol.*, Vol. III, p. 299

1853. *Otula ellipsoides*, d'Arolhac and Hime, *loc. cit.*, p. 330, Pl. XXXIII, figs. 0-8

Dimensions.

[illegible]

Occurrence.—Upper Ranikot, lower fossiliferous band in zone 2; three miles east of the old coal-pit near Leilan (Fedden, ^{6, 200}₁₂₇₉).

Remarks and comparison with other species.—Amongst the numerous forms illustrated in d'Archiac and Haine's Memoir, the one which, by its regularly ellipsoidal shape, most nearly recalls our specimens, is *Ovula ellipsoides*. The authors of the memoir were only acquainted with casts, and, not knowing of the existence of crenulated folds on the outer lip and columellar margin, they failed to refer it to its proper genus *Cypræa*. The projection of the outer lip beyond the summit shows that it belongs to the section *Eocypræa*. It differs from *E. inflata*, Lamk. (middle and upper eocene of Europe), by its more elliptical outline, and by the deflection of its columellar folds; the internal depression of the columellar margin is slightly marked. The Indian fossils which d'Archiac and Haine had already referred to the genus *Cypræa*, are not members of the section *Eocypræa* to which belongs *C. ellipsoides*; they have their summit notched as well as their anterior extremity, and are referable therefore to the section *Bernardia*, Jousseaume.

Comparison with other species.—D'Archiac and Haime have invariably described under the generic name *Ovula*, a series of casts of *Cypræida*, which evidently can only belong to the genus *Gisortia*: the margins of their aperture are not crenulated, and the spire is invisible whenever the shell is preserved. So far as is known, these specimens never show, however, those posterior prolongations and appendices that characterise the species of *Gisortia* from the neighbourhood of Paris; but their absence, and also the truncated and indistinctly notched condition of the base of the aperture, are due to the unsatisfactory state of preservation of the specimens. D'Archiac has compared his species with *G. tuberculosa*, DuRoi, from the lower eocene, which differs essentially by its dorsal protuberances; also with *G. gigantea*, Goldfuss, which is more conical and more swollen posteriorly. The dimensions given for the type are: height, 83 mm., diameter, 65 mm., which, it will be seen, correspond fairly closely with those of the largest of our specimens.

Section: *AMPELOGLADIUS*, Cossmann, 1889.

Description.—Large, slender, ovoid-fusiform; spire elongated, regularly conical; spire whorls flat, their height equal to two-fifths of their width, separated by linear sutures bordered by a thin depressed swelling; they bear straight, axial ribs, most clearly visible anteriorly, rather irregular, constricted towards the anterior suture, interspersed with coarse varices which do not coincide from whorl to whorl. Body-whorl very large, ventricose, compressed, gibbous opposite the outer lip, so that its width exceeds its thickness; its whole surface is smooth. Aperture terminated at its posterior angle by a long channel, which extends almost as far as the penultimate whorl; columella excavated; columellar margin forming a thin callous swelling, almost detached from the base; outer lip sinuous, externally bordered by a broad callus.

Probable height	85 mm.
Width	32 "
Thickness	24 "

12

Remarks.—Although the solitary specimen of this species has its aperture half broken, yet its generic attribution gives rise to no hesitation. It is of considerable interest as it indicates the presence in India of a section that hitherto seemed restricted to the Paris basin, the Loire-Inférieure, and Switzerland. The prolongation of the outer lip recalls that of the bartonian *R. athleta*, d'Orb., though with a lesser degree of curvature; moreover, the spire bears obsolete ribs and shallow varices that do not exist in the generic type; but the general shape of *R. Morgani* is quite identical with that of the Parisian species, and not nearly so slender as that of *Rostellaria*, *sensu stricto*, whose spire is slightly extraconical. The feeble development of the wing, which does not even reach the total height of the penultimate whorl, readily distinguishes *R. Morgani* from the species belonging to the sub-genus *Hippocrene* which is characterised by a widely expanded wing.

The fragmentary cast doubtfully referred by d'Archiac and Haime to *Rostellaria columbaria* (*loc. cit.*, Pl. XXX, fig. 12 a) might possibly represent an *Amplogadus*. But it probably was obtained from a different geological horizon, that of the Laki or Khirthar limestones in which some at least of these fossils certainly belong to the genus *Hippocrene*, and are therefore closely related to *Rostellaria columbaria*. Mr. Vredenburg informs us that in the "Laki limestone" which he regards as Lutetian and which is newer than the Ranikot, he has observed a similar cast bearing the impression of a very large *Hippocrene*-shaped wing, which speaks in favour of the accuracy of d'Archiac and Haime's interpretation.

Genus: CALYPTROPHORUS, Conrad, 1857.

CALYPTROPHORUS INDICUS, sp. nov., Pl. V, figs. 1, 2; Pl. VIII, figs. 3, 3a.

1879. *Rostellaria columbaria*, Lamk., *nat. ?*, in Blanford and Feilden (non d'Archiac and Haime), *Mem. G.S.I.*, XVII, pp. 144 and 208.

1906 *Calyptrophorus* sp., Vredenburg *Rec. G.S.I.*, XXXIV, p. 187.

Description.—Large, slender, ovoid-conical; spire elongated, subulate, conical; whorls scarcely convex, their height not exceeding two-fifths of their width, separated by superficial sutures almost concealed beneath the callous enamel that coats the spire. Body-whorl large, oval, compressed at its base, which is convex, and declivous towards the neck. Aperture narrow, fusiform, anteriorly ending in a sharp rostrum, which happens to be broken in the specimen selected as the type; outer lip thin, aliform, produced backwards along the groove formed by apposition with the backward prolongation of the inner lip, and then merging into the thickened enamel of the columellar margin which spreads over the whole base, and almost on to the dorsal surface of the shell, constituting a thick knob, callous and flattened; this layer of enamel extends up to the apex of the spire, and crosses over to the opposite side, till it reunites with the basal callus, so that only a very small circular area laterally situated remains free from this coating of enamel.

Dimensions.

Height without the rostrum	. . . . .	about 60 mm,
Width	. . . . .	28 "
Thickness	. . . . .	23 "

Occurrence.—This remarkable shell occurs in great abundance in the lowest zone of the marine beds constituting the Upper Ranikot, as has already been noticed by Blanford. The figured type was collected by Fedden in the undersearp of Jakhmari peak in the Laki range ($\frac{a}{17} \frac{230}{-}$) where numerous specimens of the same species were also obtained by Dr. Noelling ($\frac{k}{0.3} \frac{7}{-}$). Other localities are: east of Kandaira (Fedden, $\frac{a}{137} \frac{220}{-}$ and $\frac{a}{141} \frac{280}{-}$); north of Leilan coal-pit (Fedden, $\frac{a}{132b} \frac{240}{-}$). It has also been found in the uppermost beds of Jhirak where, however, it is rare (Vredenburg, $\frac{k}{106} \frac{7}{-}$).

Remarks and comparison with other species.—The cast doubtfully referred by d'Archiac and Haime to *Rostellaria columbiana*, Lamk., does not belong to the present species as stated erroneously by Blanford and Fedden, but probably to a species of *Hippocrene*, as has already been mentioned when describing *Rostellaria Morgani*, nobis. Moreover, as already mentioned, this cast is not of Ranikot age, but belongs to one of the overlying Lutetian limestones. The fossils from the Ranikot series included amongst the material described by d'Archiac and Haime usually have the shell preserved.

In addition to one form from the Belgian Montian, the species of *Calyptrophorus*, so far described, are restricted to the Cretaceous of India and Brazil, and the Eocene of Alabama. *Calyptrophorus indicus* when compared with the two American Eocene species, appears more ventricose and less aciculate than *C. velatus*, Conrad, less ventricose and with a less extraconic spire than *C. trinodifer*, Conrad. The cretaceous species, *C. palliatus*, Forbes, from Southern India, has a much shorter spire, and a more depressed body-whorl than the eocene fossil from Sind, which it nevertheless resembles owing to the extent of its callosity, and the situation of its callous knob; only its base is rounded and anteriorly excavated, instead of oval and declivous as in *C. indicus*. *C. chelonites*, White, from Brazil, is too incomplete for comparison: its spire is more conical than that of *C. indicus*. Mr. Vredenburg informs us that an undescribed form resembling *C. indicus*, but of much smaller size, occurs in the cretaceous "*Cardita Beaumonti* beds" of Sind.

CALYPTROPHORUS HOLLANDI, sp. nov., Pl. IV, fig. 20.

Description.—Size moderate, shape rather depressed; spire elongated, conical, consisting of about eight convex whorls whose height is a little less than half their width, separated by deep sutures, ornamented with thin, crowded, curvilinear striae of growth. Body-whorl large, angular at the base which is rounded; the suture is surrounded by a more or less prominent swelling upon which the lines of growth are more pronounced than on the remainder of the whorl; in front of the periphery angle,

the base is ornamented with concentric threads of alternating size; the body-whorl also bears a thick varix, not opposed to the aperture; columella excavated. The prolongations of the external lip and columellar margin constitute a groove with wide-spaced margins, which does not reach quite to the apex of the shell, and on whose external surface the threads of the body-whorl are continuous. The columellar enamel invades a portion of the ventral surface of the spire, and gradually fades away without any sharp boundary.

Dimensions.

Probable height	.	.	.	.	.	.	.	.	.	35 mm.
Diameter	.	.	.	.	.	.	.	.	.	13 "

Occurrence.—Uppermost Ranikot (zone 4). Jhirak (Fedden, ^{11.20}/₁₂₁₈; Vredenburg, ^{5.5}/₁₆₇); left bank of Indus opposite Jhirak (Vredenburg, ^{8.2}/₂₆).

Comparison with other species.—Although all the specimens have the aperture damaged, the Jhirak species seems to be really a *Calyptraphorus*. It differs from *C. velatus* of Alabama, by its much more depressed shape, its non-gibbous spire, and the swelling that surrounds the suture of the body-whorl. The dorsally situated varix is very obsolete and does not much resemble the nodosities of *C. trinodifer*, the other cocene species from the United States.

Genus: RIMELLA. Agassiz, 1840.

RIMELLA PRESTWICHI. d'Archiac and Haime, Pl. IV. figs. 21, 22.

1873 *Rostellaria Prestwichi*, d'Archiac and Haime, loc. cit., p. 312, Pl. XXX figs. 7, 8.

Description.—Size moderate, shape slender, fusiform; spire elongated, conical or slightly conoidal, consisting of seven whorls whose height equals seven-tenths of their width, feebly convex, separated by deep sutures, ornamented with thin, constricted, rather crowded, oblique, axial ribs, regularly distributed throughout the whorls, interspersed with a few thick irregular varices. Body-whorl large, including more than half the total height, with an oblique varix on the ventral region, oval at its base which is excavated only behind the neck, and upon which the ribs gradually disappear and are replaced by spiral grooves revolving round the neck. Aperture fusiform, narrow, with the posterior angle choked by the columellar callosity and the prolongation of the outer lip, anteriorly ending in an acute rostrum bent towards the left; outer lip thin, rather sinuous, posteriorly produced into a broad expansion which extends up to the apex of the spire which it completely conceals, and then crosses over to the opposite side which it follows nearly to the penultimate whorl; columella smooth, approximately rectilinear, oblique; columellar margin very callous, rather narrow, with a distinct boundary on the base, but extending also on to the ventral surface as a thin layer which spreads up to the varix, and completely masks the axial ribs.

Dimensions.

Height	40 mm.
Diameter	18 „

Occurrence.—Zone 2, amongst gypseous shales, three miles east of the old coal-pit near Leilan (Fedden, $\frac{0}{126} \frac{280}{a}$). Very common in the uppermost beds (zone 4), of the Ranikot: Jhirak (Fedden, $\frac{0}{121} \frac{280}{a}$; Vredenburg, $\frac{K}{100} \frac{7}{b}$); left bank of Indus opposite Jhirak (Vredenburg, $\frac{K}{320} \frac{7}{b}$).

Comparison with other species.—Although this shell is very closely related to the common eocene species of Europe, *R. fissurella*, Lamk., yet it is distinguished by a whole series of differential characters: the axial ribs are much finer and much more numerous; the aperture is narrower and taller; the depression adjacent to the rostrum is not so deeply notched; the prolongation, upon the spire, of the outer and inner lips, constitutes a more prominent raised lamella, and extends further down the opposite side of the spire. The rostrum is broken in all the adult specimens which we have examined, but it is preserved on some of the younger ones, when it appears sharp and less deflected to the left than in *R. fissurella*. Even on the most perfectly preserved individuals, it is impossible to detect any revolving striæ between the axial ribs, while in *R. fissurella*, these intervals are delicately striated; the only spiral ornaments of *R. Prestwichi* are the basal striations of the body-whorl. The axial ribs are continued upon the wing with a slight increase of width of their spacing; on the posterior region of this aliform margin, they are replaced by oblique folds, representing the successive lines of adjustment between the wing and spire before commencing its phase of senile development after which it envelopes the apex, and advances upon the opposite side. Lastly the groove which, from the posterior angle of the aperture, very distinctly separates the callosity of the outer lip from that of the inner one, is continued all along the crest of the wing which it divides into two adjacent lamellæ even beyond the summit.

None of the above characters exist in *R. fissurella*.

Compared with *R. duplicata*, Cossm., from the eocene of Egypt, or with *R. inæquicostata*, Boettg., from the eocene of Borneo, the Indian species is distinguished by the equal distribution of the ribs all along the spire, while in the two other species, the spacing becomes about double on the last whorl.

Of the two figures of this species published by d'Archiac and Haime, only one (fig. 7), represents a fairly well preserved individual, very similar indeed to those that we have figured, only with the aperture less complete than in our plesiotype.

RIMELLA FUSOIDES, d'Archiac, Pl. IV, figs. 18, 19; Pl. VII, fig. 46.

1850 *Rostellaria fusoides*, d'Archiac, *Histoire des progrès de la Géologie*, Vol. III, p. 294.

1853. *R. fusoides*, d'Archiac and Haime, *loc. cit.*, p. 313, Pl. XXX, figs. 4, 5.

Description.—Size less than medium; shape fusiform, rather conoidal; spire turriculated, not very elongated, with obtuse apex, consisting of seven or eight gyrations

which are at first feebly convex and smooth, separated by deep sutures, their height equal to two-fifths of their width; at about the penultimate whorl, numerous ribs make their appearance: they are narrow, very close-set, scarcely curvilinear, and the intervals between them are, at first, smooth. Body-whorl occupying nearly two-thirds of the total height, feebly ventricose, oval at its base, ornamented like the preceding whorl with the addition of very fine spiral striations in the intervals between the axial ribs, best seen in the neighbourhood of the aliform expansion, on whose outer surface they expand fanwise: on the base they somewhat abruptly give place to spiral cords crossing the axial folds which persist as far as the neck. Aperture obliquely elongate, rather narrow, terminated posteriorly by a groove, and anteriorly by a beak adjacent to an inflected rostrum; outer lip thickened and expanded, with a denticulated crest along its margin, bent in front and to the left of the axis, posteriorly produced up to the apex of the spire which it covers; columella excavated, with a callous margin almost detached, and posteriorly joined on to the opposite lip.

Dimensions.

Height	.	.	.	.	.	.	.	.	.	.	.	.	.	.	17	mm
Breadth	.	.	.	.	.	.	.	.	.	.	.	.	.	.	8.5	"
Thickness	.	.	.	.	.	.	.	.	.	.	.	.	.	.	6	"

Occurrence.—Uppermost Ranikot (zone 4): Jhirak (Fedden, α_{121a}^{260} ; Vredenburg, $\gamma_{1,0}$).

Comparison with other species.—D'Archiac and Haime's figures only represent incomplete specimens. It is by means of the principal character mentioned by these authors, the obliteration of the ribs on the completely smooth early whorls, that we have been able to refer to this species, the remarkable neotype which we have figured. The elegant lattice of spiral threads observable on the body-whorl of this neotype, is invisible on the other incomplete specimen which, in every other way resembles those figured by d'Archiac and Haime.

R. fusoides is easily distinguished from *R. fissurella*, by its smooth early whorls, its much more crowded ribs, and its spiral striations. Its depressed conoidal shape, its spiral striations, and the serrated crest of its outer lip, distinguish it from *R. Prestwichi*.

We feel inclined to think that *R. Jamesoni*, d'Archiac and Haime, is a more complete specimen of *R. fusoides*, in which the ribs only begin to appear on the ventral surface of the body-whorl. There does not seem to be much need of a distinct name for this variety.

RIMELLA HOLLANDI, sp. nov., Pl. IV, fig. 23.

Description.—Size moderate, shape somewhat depressed; spire elongated, conical or slightly conoidal; seven very convex whorls, whose height is half their width, somewhat depressed at the suture which is deep and bordered by a ridge; ornamentation consisting of curvilinear ribs, fine and very crowded, posteriorly interrupted by a

spiral groove which separates a small crenulated ridge encircling the suture; the remainder of the shell is marked with exceedingly fine spiral striations which do not cross the axial ribs. Body-whorl large, constituting nearly two-thirds of the total height, with a convex base upon which the ornamentation persists almost up to the neck of the canal, while at the anterior region are some revolving threads producing square granulations at their intersection with the ribs. Aperture small; outer lip posteriorly produced into a rather narrow wing reaching the apex, but not extending very far on to the opposite side of the spire; columellar edge callous somewhat detached from the base, coalescing posteriorly with the prolongation of the outer lip.

Dimensions.

Height	32 mm.
Diameter	13 ..

Occurrence.—Uppermost Ranikot, Jhirak (Fedden, $\frac{a}{121} \frac{240}{a}$).

Comparison with other species.—This species cannot be mistaken for *R. Prestwichi* or *R. fusoides*, from both of which it is clearly distinguished by its depressed shape and especially its completely different ornamentation: instead of lamellar ribs like those of *R. Prestwichi*, *R. Hollandi* bears thin curvilinear ones; the sutures are encircled by a small crenulated ridge which replaces the sutural groove of *R. fusoides*. Moreover, the ornamentation commences with the earliest stages, while *R. fusoides* has its first whorls smooth. Amongst the species of the same group described by d'Archiac and Haime, we do not find any closely related to *R. Hollandi*: *R. Jamesoni* which somewhat resembles it in general outline, has the spire smooth, and the sutures non-crenulate. *R. cf. rimosa*, Sow., is represented only by fragments ornamented with coarser and wider-spaced spiral striations.

Genus: TERESELLUM, Klein, 1753.

TERESELLUM DISTORTUM, d'Archiac and Haime, Pl. V, figs. 6, 7, 11.

1853 *T. distortum*, d'A. and H., *loc. cit.*, p. 334, Pl. XXXII, figs. 10, 10 a.

Description.—Large, narrow, slender, fusiform; spire long, narrow, conical; whorls somewhat convex, very tall, increasing irregularly, separated by very oblique channelled sutures. Body-whorl very large, constituting about five-fifths of the total height, with slightly attenuated base. Aperture narrow, columella feebly excavated.

Dimensions.

Probable height	55 mm.
Diameter	11 ..

Occurrence.—Upper Ranikot. Zone 3: north of Leilan coal-pit (Fedden, $\frac{a}{120} \frac{280}{a}$). Jhirak (Vredenburg, $\frac{x}{122} \frac{9}{a}$). Zone 4: Jhirak (Fedden, $\frac{a}{124} \frac{240}{a}$; Vredenburg, $\frac{x}{170} \frac{7}{172}$).

Remarks.—With regard to the material at our disposition, we are not much more fortunate than our predecessors though they described the species only from internal casts: the specimens which we have examined are still more fragmentary than theirs, so that they seem to consist of a smaller number of whorls than the ones figured in d'Archiac and Haime's work; one of them is more ventricose and conoidal, with sutures more oblique than the two others; but such differences would not justify the separation of a species or even of a variety; moreover, the appearance varies according to the age and state of preservation of the specimens. None of the eocene species of Europe have such a distended spire as *T. distortum*: the slender and polygyrate outline of its spire is quite characteristic.

Section: *SERAPHS*. Montfort, 1810.

TEREBELLUM (SERAPHS) LANCEOLATUM. sp. nov., Pl. V, fig. 8.

Description.—Large, narrow, slender: spire concealed; body-whorl constituting the whole shell; aperture tall, wide, canaliculated at the posterior angle; outer lip with a very sharp margin, produced up to the apex, and apparently continued beyond it on the opposite side. Columella rectilinear.

Dimensions.

Probable height	.	.	.	.	.	.	.	.	.	.	60 mm.
Diameter	.	.	.	.	.	.	.	.	.	.	13 "

Occurrence.—Uppermost Ranikot (zone 4), Jhirak (Fedden, $\frac{0}{124} \frac{2-0}{8}$).

Remarks.—We have referred this species to the section *Seraphs* of the genus *Terebellum*, although we have not been able to study the details of the aperture, especially the anterior extremity. Should this anterior extremity terminate in a sharp rostrum instead of being truncated like that of *Terebellum*, this shell would belong rather to the genus *Semiterebellum* related to *Hippocrene*, which it recalls, indeed, by the posterior channel of the aperture. At any rate, d'Archiac and Haime's Memoir does not contain any forms referable to *T. lanceolatum* which is characterised chiefly by its acuminate spire: *T. obtusum* J. de C. Sow., for instance, has it rounded and short.

Section: *MAURYNIA*, de Gregorio, 1880.

TEREBELLUM (MAURYNIA) FLICATUM, d'Archiac and Haime, Pl. V, figs. 3-5.

1853 *T. plicatum*, d'A. and H., *loc. cit.*, p. 334, Pl. XXXII, figs. 17, 18, 22.

Description.—Large; elongated, somewhat ventricose towards the posterior third; spire concealed; body-whorl constituting the whole shell, ornamented with straight oblique ribs, prominent and widely spaced, abruptly interrupted at half the height of

the shell; outer lip forming a channel which is produced up to the apex, but does not seem to be continued on the opposite side. In a few individuals the sutures are distinctly visible. When this occurs, the dorsal ribs of the body-whorl are thicker than those of the previous whorls, and two or three times further apart.

Dimensions.

Height	70 mm.
Diameter	16 „

Occurrence.—Upper Ranikot: upper beds of zone 3, Jhirak (Vredenburg, $\frac{K. 9}{817}$); zone 4, hilly ground north by east of Petianni, below the big scarp of white limestones, north-west of Kotri (Fedden, $\frac{a 280}{13a}$), Jhirak (Fedden, $\frac{a 280}{121 a}$; Vredenburg, $\frac{K. 2}{171}$), left bank of Indus opposite Jhirak (Vredenburg, $\frac{K. 2}{316}$).

Remarks.—This fossil is as extraordinarily abundant in the upper zones of the Upper Ranikot, as *Calyptraphorus indicus* in the lower zones of this sub-division. Instead of the immature casts figured by d'Archiac and Haime, we have been able to study specimens with the shell preserved, reaching the maximum size, and showing the coarse ribs of the body-whorl, with which these authors were unacquainted. This species is the original of the section *Mauryna*, de Gregorio (1880), and the present specimens enable us to complete its diagnosis: hitherto there had remained some doubt concerning the existence of the channel connected with the outer lip, extending up to the summit, and whose external edge gives rise to the axial folds at each interruption of growth.¹ It is now evident that this disposition indicates a close relationship to *Semiterebellum* and confirms the subgeneric distinctness of *Mauryna*, at least relatively to *Terebellum*, *sensu stricto*.

The Indian species is much narrower and much more elongated than *T. pliciferum* Bayan, from the Priabonian of Venetia.

Family: *APORRHAIIDÆ* H. and A. Adams

Genus: *CHENOPUS*, Philippi, 1836.

Section: *MAUSSENETIA*, Cossmann, 1904.

CHENOPUS (*MAUSSENETIA*) *DIMORPHOSPIRA*, sp. nov., Pl. IV, figs. 26-28;
Pl. VIII, figs. 4, 4a.

Description.—Size moderate: shape ventricose, biconical without the wing; spire moderately elongate, conoidal, with dimorphous ornamentation; the spire consists of

¹ Cossmann, *Essais de Paléoconchologie comparée*, VI, p. 46 (1904).

seven or eight whorls, the earliest of which are convex and smooth, the next ones spirally striate, the later ones angular towards their lower (posterior) third; the height of each whorl equals nearly half its width; sutures linear. The later whorls are ornamented with seven coarse spiral threads, of feeble relief, equally spaced, somewhat wider than the intervals between them. Body-whorl large, globose, gibbous on the side opposite to that of the wing, slightly excavated beneath (behind) the prominent keel which corresponds with the third spiral thread counted from the suture; base oval, declivous, ornamented with spiral threads which are thicker and more crowded than those of the spire, and which persist on to the canal. Aperture very narrow, closely following the curve of the columella, bearing the remains of a winged expansion which was probably keeled like the body-whorl, and which is prolonged up to the apex of the spire; columellar callus broadly spread out over the base, and bounded by a keel along the neck; rostrum and digitations unknown.

Dimensions.

Probable height	50 mm.
Diameter without the wing	24 „
Thickness	20 „

Occurrence.—Upper Ranikot, Jhirak: zone 3 (Vredenburg, $\frac{K. 9}{330}$), zone 4 (Fedden, $\frac{G. 2-3}{1214}$; Vredenburg, $\frac{K. 2}{151}$). According to Mr. Vredenburg, this species, or one very closely related, occurs also abundantly, as casts, in the Laki limestone overlying the Ranikot group.

Comparison with other species.—The fragments originally sent to us (Pl. IV, figs. 26-28) recalled *Sulcogladus* on account of their ornamentation and keel, both of which closely resemble the same features in *Rostellaria goniophora* Bellardi, the type of the subgenus *Sulcogladus*. But this impression was dispelled by our examination of a much more complete specimen subsequently forwarded to us by Mr. Vredenburg, showing the columellar callus, and the remnants of a wing extending up to the apex of the spire (Pl. VIII, figs. 4, 4a): the shell must evidently be classified with the subgenus *Maussenetia*, Cossm., (*Essais Pal. Comp.*, 1904, fasc. VI, p. 118), the type of which is *M. Staadti*, Cossm., characterised by the same ornamentation, with the same keel and gibbosity on the body-whorl. Nevertheless, *Chenopus dimorphospira* is much more ventricose than the European species, and its threads are more regular. No comparison can be established in the case of the wing which has disappeared in the Indian specimens.

It is very interesting to find in the Eocene of India, a representative of this paleocene form of the Paris basin; perhaps it will ultimately be shown that the species of *Sulcogladus* from the nummulitics of the Mediterranean (none of which have yet been found with the wing preserved), will have to be united with *Maussenetia*, indicating stages in the migration of this form.

Family: *CERITHIDÆ* Fleming.

Genus: *CERITHIUM*, Bruguière, 1789.

Section: *CAMPANILE*, Bayle, 1884.

CERITHIUM (*CAMPANILE*) *SUBSEMICOSTATUM*, d'Archiac and Haime, (?), Pl. V, figs. 9, 10.

1853. *Cerithium subsemicostatum*, d'A and H., *loc. cit.*, p. 300, Pl. XXIX, fig. 5

Description.—Large, depressed; spire elongated, conical, consisting of very low whorls, whose height is only one quarter of their width; these whorls are feebly convex, they overlap one another to a considerable extent, and they are separated by deeply channelled sutures; their posterior margin has the shape of a narrow step-like band; they are ornamented with thick oblique ribs, very obsolete, of the same width as the intervals between them, more prominent on the later whorls. Body-whorl low, with convex base; columellar margin with two prominent lamellar folds, of which the anterior one is oblique, the other (the parietal one), very distant from the first, and horizontal.

Dimensions.

Height	60 mm.
Diameter	35 "

Occurrence.—Upper Ranikot, zone 2, three miles east of the old coal-pit near Leilan (Fedden, $\frac{a}{125-2}$); zone 3, same locality (Fedden, $\frac{a}{127}$), and Jhirak (Vredenburg, $\frac{x}{23}$).

Remarks.—D'Archiac and Haime have described *C. subsemicostatum* from the external impression of a crushed fragment showing no remnant of the aperture. Their diagnosis does not differ however from ours, except in one particular, relatively to "the system of very delicate capillary striations occupying the whole surface." Owing to the weathered condition of our specimens, it has not been possible to ascertain whether the whorls are really striated in a spiral direction. Still, in spite of this small difference, they appear to belong to d'Archiac and Haime's species. It should be noticed, however, that the type described by our predecessors was obtained from an entirely different horizon, since, as mentioned by them, it is associated, in the same matrix, with *Nummulites garauensis*, and is therefore an oligocene fossil. We have therefore placed a query after our identification.

D'Archiac and Haime have compared their species with *C. subsemicostatum*, Desh., from the Thanetian of the neighbourhood of Beauvais, though they recognise that it differs by its folds extending from suture to suture, while "in the species from the Seine basin, they stop at half the height of the whorls, the striations continuing uninterrupted on the other half." To this difference (supposing, of course, that our specimens correspond really with d'Archiac and Haime's species) must be added the capital one that the two fossils evidently do not belong to the same sub-genus,

C. semicostatum being a *Vulgocerithium*, while the Indian fossil is an undoubted *Campanile*, as shown by its columellar and parietal folds. D'Archiac and Haime also notice that "judging by the illustration, which is not quite satisfactory, one might be tempted also to compare this *Cerithium* with *C. cornucopiae*, Sow. (*Miner. Conchol.*, Pl. CLXXXVIII, fig. 1), but a comparison with the original specimen shows no real analogy." Nevertheless, our specimens, belonging as they do, to the sub-genus *Campanile*, are truly related to the above mentioned species which belongs to the same sub-generic division, and whose last whorls also bear large curvilinear ribs, which are, however, more nodular and curved anteriorly than those of the Indian species. The apex of the spire is missing in all our specimens, so that we cannot verify whether they possessed that dimorphism of outline and ornamentation which characterises not only *C. cornucopiae*, but generally all species of *Campanile* in which the earlier whorls are flat and ornamented with granular striations, while the later ones are in most cases convex, tenaced, and tuberculated.

Genus: RHINOCLAVIS, Swainson, 1840.

RHINOCLAVIS SUBNUDA, d'Archiac and Haime, Pl. V, figs. 15, 16

1853 *Cerithium subnudum*, d'Archiac and Haime, *loc. cit.*, p. 301, Pl. XXVIII, fig. 17.

Description.—Size moderate, shape elongated; spire elongated, regularly conical consisting of twelve to fifteen flat whorls, whose height is equal to half their width, separated by shallow, almost horizontal sutures; the whorls are ornamented with vertical or slightly oblique ribs, widely spaced, irregularly distributed, crossed by thin, widely spaced revolving threads, of which there are about ten in each whorl: this ornamentation usually disappears on the later whorls where one only notices here and there some varicose folds. Body-whorl occupying one-third of the total height, rounded at its base which only bears spiral threads and a varix opposite the outer lip; there is a sub-carinate basal ridge revolving round the neck. Aperture wide, oval, ending anteriorly in a wide canal, and posteriorly in a narrow channel which is produced internally; outer lip sinuous, reflected outwards; columella excavated, smooth; columellar margin callous, slightly detached from the base.

Dimensions.

Height	62 mm.
Diameter	17 ..

Occurrence.—Upper Ranikot. Zone 2: three miles east of the old coal-pit near Leilan, amongst gypseous shales (Fedden, $\frac{0}{15} \frac{2}{20}$). Zone 2 or 3: Hotian lak (pass), 10 miles south of Ranikot, (Fedden $\frac{0}{15} \frac{2}{20}$). Zone 3: Jhirak (Vredenburg, $\frac{K}{32} \frac{5}{10}$). Zone 4: Jhirak (Fedden, $\frac{0}{124} \frac{20}{20}$, Vredenburg, $\frac{K}{110} \frac{7}{125}$).

Comparison with other species.—As already noticed by d'Archiac and Haime, the fossil which they figured as the type of *Cerithium subnudum*, is an immature specimen lacking the aperture, but it agrees fairly well with the earlier whorls of our specimens. Some of the fragments examined by these authors must have been more characteristic than the one figured, to enable them to declare that "this species may be regarded as representing in the seas of that part of the globe, Lamarck's *Cerithium nudum* so common in the "calcaire grossier" of the Paris basin." (*Loc. cit.*, p. 301.) Nevertheless, the Indian species is distinguished by its more pronounced axial pleats, and less distinct spiral striation. Regarding their further remarks on the species, d'Archiac and Haime were at a disadvantage owing to the imperfection of their material. Far from being rare, as stated by them, the shell seems to be rather plentiful and extremely variable, so that one might easily define a number of different species, were they not all connected by intermediate gradations.

Like the closely related species from the Lutetian, this shell belongs to the genus *Rhinoclavis*, Swainson (*Vertagus*, Klein), and probably, owing to its non-plicate columella, to the group for which Mr. Vignal has recently proposed the name of *Pseudovertagus*,¹ but the latter distinction is very insecure, for there exist many forms with more or less obsolete folds. We will content ourselves, therefore, with the reference to *Rhinoclavis*.

RHINOCLAVIS ANGYSTOMA, (d'Archiac and Haime), Pl. V, figs. 12-14.

1873 *Rostellaria angustoma*, d'Archiac and Haime, *loc. cit.*, p. 314, Pl. XXX, figs. 14, 15.

Terebra contorta, *ibid.*, p. 321, Pl. XXXI, fig. 18; Pl. XXXII, fig. 10.

Description.—Large, narrow, elongated, pupiform; spire long, subulate, conoidal, consisting of fifteen to twenty slightly convex whorls, whose height equals or even exceeds two-thirds of their width; they are separated by deep very oblique sutures, anteriorly bordered by a narrow declivous band; the surface is ornamented with twelve to fifteen very obsolete, regularly distributed, close-set spiral threads, often missing on the last whorls; the early whorls also show axial folds. Body-whorl very tall, oval, attenuated at its base, with a rounded feebly raised ridge round the neck. Aperture feebly expanded, oval, anteriorly terminated by a broad sub-canalieulated depression, posteriorly bearing a narrow channel deeply cutting into the parietal callus; outer lip thin, without a distinct rim, sinuous, posteriorly detached together with the channel; columella excavated, apparently non-plicate; columellar margin callous, feebly spreading, clearly detached from the base and from the basal ridge.

Dimensions.

[illegible]

¹ Vignal, *Liste des coquilles des environs de Djibouti*, p. 5 (1901), Cossmann, *Essais de Paléoconchologie comparée*, VII, p. 81 (1903).

Occurrence.—Upper Ranikot. Zone 2: three miles east of the old coal-pit near Leilan, amongst gypseous shales, (Fedden, ^a₁₋₂²⁰). Zone 4, Jhirak (Vredenburg, ^k₁₄⁵).

Remarks.—The turriculated shell which d'Archiac and Haime have described as "*Rostellaria angistoma*" is evidently a *Rhinoc'aris*, as indicated, indeed, by the shape of the aperture in the original figure illustrating it (Pl. XXX, fig. 14, of d'Archiac and Haime's Memoir) only the sutures are not drawn sufficiently obliquely in this figure in which the penultimate whorl seems very much out of proportion, the specimen being, perhaps, accidentally distorted. There is no serious doubt, however, as to the specific identity of our specimens with the shell represented in figure 14, the apical whorls of which are axially plicated. Figure 15 of the same plate, which shows the sutures more oblique and the whorls partly concave, partly convex, probably represents a weathered specimen. The same authors have also figured under the name of "*Terebra contorta*" two more fragments of the same fossil, in which the sutures are represented as more oblique, and the small sutural band is clearly indicated. This species is readily distinguished from *Cerithium subnudum*, by its oblique sutures and by the absence of varices on the last whorls; its basal ridge is also more obsolete.

Genus indet., sp. indet., Pl. VI, figs. 1, 2.

Description.—Large, turriculated, narrow; spire elongated, slender, regularly conical, consisting of broad whorls whose height is equal to about one-third of their width, separated by shallow, feebly incised sutures, ornamented with big nodular tubercles, spaced wide apart, rather nearer the posterior than the anterior suture. Body-whorl large, with convex base; its surface is weathered, and there appear to be some obscure indications of spiral cords, and of sinuous striae of growth, close to the row of nodular tubercles. The aperture is damaged, but does not appear to have been anteriorly canalienlated.

Dimensions.

Height of fragment	70 mm.
Diameter	35 ..

Occurrence.—Uppermost Ranikot, Jhirak (Vredenburg, ^k₁₅⁵).

Remarks.—This specimen closely resembles in outward appearance d'Archiac and Haime's figure of *Vicarya Verneuli*, d'Arch. (loc. cit., Pl. XXVIII, fig. 4), a fossil whose classification still remains ambiguous. According to Mr. Douvillé, this form does not seem to belong to the family *Cerithiidae*, but is more probably one of the *Melaniidae*.¹ Moreover, it is not, as supposed by d'Archiac and Haime, an eocene form. Jenkins, in 1864, described a closely similar species occurring in Java, amongst beds which he considered miocene, and was led thereby to attribute a similar post-eocene age to the Sind fossil (*Quart. Journ.*, G. S., XX, p. 64). This conclusion was confirmed by Blanford and Fedden's survey of Western Sind. In Medlicott and Blanford's "Manual of the Geology of India," (1879), *Vicarya Verneuli* is

¹ Cossmann, *Essai de Paléontologie comparée*, VII, p. 65 (1906)

figured as one of the typical Gáj fossils (the figure being merely a copy of that published by d'Archiac and Haime). According to Mr. Vredenburg, the only specimen that can be traced in the Geological Museum in Calcutta, with exact data as to its geological horizon, was obtained by Fedden in beds which he regarded as uppermost Gáj, and which overlie the whole thickness of the typical Gáj formation. Even supposing that the bulk of the Gáj is upper Aquitanian, this fixes the age of this specimen as not older than Burdigalian, which entirely agrees with Jenkins' conclusion. (Jenkins speaks of the Java beds as "upper miocene," but the discrepancy is only apparent, because the same author speaks of oligocene strata of the horizon of *Nummulites intermedius* as "lower miocene," in accordance with the nomenclature in vogue at the time when he wrote.)

In consequence of this well established difference of geological age, and of the imperfect condition of the fossil briefly diagnosed above, we have refrained from classifying it. The shell is broken at the very spot where one would have to look for the generic criterion of *Vicarya*, that is the peculiar pleuromid sinus at the margin of the outer lip.

The number of nodular tubercles is eight to each whorl, the same as in *Vicarya Verneuli*, but they seem more distant from the suture and more rounded (perhaps as a result of weathering); after attentively examining the spire, we have failed to discover any indication of a sinuous line of growth, or of the band formed by the scar of the sinus, which is well indicated in the figures of d'Archiac and Haime's monograph: it is only on the base that one can guess the existence of a few oblique and curvilinear striations of growth in front of the row of tubercles. There is no indication, either, of the granular cord occupying the same position in d'Archiac's type. Lastly, on the ventral face on the body-whorl, the shell is missing at the very spot where the figure of *V. Verneuli* indicates a greatly developed columellar and parietal callosity extending as far as the penultimate whorl; the existence of this feature, consequently, must remain doubtful.

Under the circumstances, we are compelled to postpone any final decision regarding this interesting fossil which has about the same dimensions as *V. Verneuli*, but a more conical shape and more oval base, so that, if it should belong to the same genus it must at least represent an entirely distinct species.

Family: *TURRITELLIDÆ* Gray.

Genus: *TURRITELLA*, Lamarek, 1799.

TURRITELLA HALAENSIS, Cossmann, Pl. V, figs. 20, 21.

1850. *Turritella* undet., d'Archiac, *Histoire des progrès de la Géologie*, Vol. III, p. 280.

1853. *Turritella affinis*, d'Archiac and Haime, *loc. cit.*, p. 205, figs. 16-19 (non *T. affinis*, Müller 1851, *Petr. Arch. Kreide*, II, p. 31, Pl. IV, fig. 11.)

1901. *Turritella halaensis*, Cossmann, *Revue crit. Paléoz.*, Vol. III, p. 107 (Rect. Nomencl.)

Description.—Large, slender, regular; spire elongated, regularly conical; angle of the spire, about 16°: whorls tall, their height nearly the same as their breadth, separated

by inconspicuous sutures; the ornamentation consists, anteriorly, of a thick, sub-erect ridge, constituted by the juxtaposition of two or more cords thicker than the granular fine threads that cover the remaining portion of the whorls, the intervals between which are occupied by two or three much finer threads, while the whole surface is delicately latticed with plications of growth which are very sinuous posteriorly.

Dimensions.

Height of figured fragment	. . . . .	65 mm
Diameter	. . . . .	16 "

Occurrence.—Uppermost Ranikot, Jhirak (Fedden $\frac{G. 240}{121 a}$).

Comparison with other species.—This species closely resembles the form figured by d'Archiac and Haime under the name of *T. affinis* (a name preoccupied in the nomenclature by a cretaceous fossil described by Muller in 1851). According to their account, this is however an oligocene species, as it is stated to be associated with *Nummulites garancensis*, and in Fedden's list, it is mentioned as characterising the oligocene "Nari group" (*Mem. G. S. I.*, XVII. p. 206). If the figures in d'Archiac and Haime's monograph are accurate, the specimens which they represent differ to some extent from the Ranikot form: the funicula constituting the anterior sutural swelling are shown as being much more rounded; the other threads are shown as more coarsely unequal; the flexuous striae of growth are missing, and the spiral angle is more open. Nevertheless, the Ranikot and Nari forms, if not identical, are closely related to one another; but instead of comparing our specimens, as d'Archiac and Haime did theirs, with *T. Deshayesi*, d'Arch., which has five regular threads and the sutures excavated instead of bulging, we think they can far more suitably be compared with *T. carinifera* Desh., which essentially characterises the Lutetian of Western Europe: only the latter, instead of a bifid sutural bulge, has a single sharp keel, which gives the whorls a different aspect; moreover, the other threads of the Ranikot fossil are perhaps more equal in size and more regularly spaced than the somewhat intermixed ones of *T. carinifera*. Our specimens do not show the base of the body-whorl. D'Archiac and Haime state that the base of their specimens is flat and grooved. Should this be the case also with the closely related Ranikot form, it would constitute another difference from *T. carinifera* whose base is slightly convex and bears a few concentric threads.

The nodular limestone of the neighbourhood of Cairo, whose age is probably Lutetian, contains a fossil which one of us has provisionally referred to *T. carinifera* (Cossmann, 1901. *Add. faune numm. Egypte*, p. 11, Pl. II, figs 5, 6, of special issue); it differs from the Ranikot form by its non-bifid, though scarcely keeled bulge, and by the sub-imbriate declivous shoulder intervening between this bulge and the suture, while the more rounded swelling of the Ranikot form abuts directly on the suture.

TURRITELLA INFRARIMATA, sp. nov., Pl. VI. figs. 6, 7.

Description.—Large, slender, narrow, regular, almost cylindrical: spire long, regularly subulate, whorls numerous, tall, their height equal to about nine-tenths of

their width, inflated towards their anterior third, posteriorly excavated, separated by deep canaliculated sutures; their surface appears to have been ornamented with numerous, irregularly distributed, obsolete threads, and by a thick ridge, constituted by the union of several threads surrounding the posterior suture.

Dimensions.

Height of a fragment consisting of four whorls	60 mm.
Diameter	16 „

Occurrence.—Said to be from Zimmiwari ravine. Probably zone 2 of the Upper Ranikot (purchased by Fedden, ¹⁸⁹⁹₁₋₃).

Comparison with other species.—Although this species is represented by a solitary fragment consisting of only four whorls and unfortunately rather weathered, it is readily distinguishable from *T. halaensis*, not only on account of its almost cylindrical outline which indicates a very long spire, but especially because the prominent revolving ridge occupies the posterior margin of the whorls instead of the anterior one, which gives the shell quite a different appearance, irrespective of the outline of the whorls which is somewhat swollen anteriorly and posteriorly excavated, instead of being uniformly rectilinear as in *T. halaensis*. Some traces of spiral ornaments subsist upon the better preserved parts of the surface, but the striae of growth are invisible.

T. infrarimata somewhat recalls *T. hybrida*, Desh., from the Suessonian of the Paris neighbourhood, in which the suture is also enucleated by a rounded ridge; but the Suessonian species also exhibits, behind the suture, a broad furrow divided by a spiral thread, no trace of which can be seen on the Indian one; moreover, the revolving threads of the latter were probably less regular than those of *T. hybrida*.

TURRITELLA ANGULATA, J. de C. Sowerby, Pl. VI, figs. 3-5.

1810. J. de C. Sowerby, *Trans. Geol. Soc., Lond.*, (2), Vol. V, Pl. XXV, fig. 7.

1832. A. d'Orbigny, *Prodr.*, Vol. III, *Etage* 20, No. 161.

1853. D. Arctif and Hahne, *loc. cit.*, p. 291, Pl. XXVII, figs. 8, 9, (non 6, 7)

Description.—Size moderate, shape rather narrow, slender, spire elongated, regularly conical; spire whorls numerous, angular, separated by deep sutures, which are even channelled on the initial whorls; they are ornamented anteriorly with a large subgranular keel and an obsolete thread on the anterior declivity in front of the angle constituted by this prominent keel; the posterior slope, excavated behind the keel, bears five or six thin, granular threads, disposed with little regularity; two of them, situated on the convexity of the posterior region, are usually more prominent than the others. Body-whorl with an additional peripheral thread. Aperture subquadrangular.

Probable dimensions.

Height	60 mm.
Diameter	15 „

Occurrence.—Upper Ranikot, lowermost beds (zone 1) east of Kandaira, Vera plain east (Fedden, $\frac{6}{156} \frac{2.20}{2}$); zone 2, amongst gypseous shales, three miles east of the old coal-pit near Leilan (Fedden, $\frac{6}{126} \frac{2.40}{2}$); uppermost beds (zone 4), Jhirak (Vredenburg, $\frac{h}{160} \frac{7}{2}$); left bank of Indus opposite Jhirak (Vredenburg, $\frac{h}{320} \frac{7}{2}$). This species has a very extensive vertical range, and occurs abundantly also in the Nari and Gáj of Sind. J. de C. Sowerby's type was collected by Grant in the Gáj beds of Kaelh.

Comparison with other species.—This species is very variable: it is not surprising therefore that in our specimens the spiral angle should seem narrower than is shown in d'Archiac and Haime's figures. Nevertheless, it is not so variable as has been supposed by the authors of the "Description", who, according to our opinion, have erroneously united J. de C. Sowerby's typical *T. angulata* with his *T. assimilis*. The latter lacks the anterior keel which is replaced by two smooth threads. Moreover, the outline of *T. angulata* is more mesaliform.

T. figolina, Carez, from the nummulitic of the Pyrenees, has a much sharper keel than the Indian species, and its whorls are flat. *T. atciuna*, d'Orb., from the same region, is also not unlike *T. angulata*, but its keel is less prominent, and the threads decorating the remainder of its surface are more regular.

TURRITELLA HOLLANDI, sp. nov., Pl. V, figs. 17-19.

Description.—Large, narrow, slender; spire long, sub-cylindrical, the spire angle of very few degrees; whorls convex, tall, their height equal to two-thirds of their width, separated by deep sutures behind which is a small sub-angular thread: the whorls are ornamented with three thin equidistant, prominent keels, sometimes sub-granular, separated by concave intervals, with sinuous striations of growth.

Dimensions.

Height of largest fragment	. . . . .	60 mm.
Diameter of the same	. . . . .	12 "

Occurrence.—Lowest beds of Upper Ranikot, north of Leilan coal-pit (Fedden, $\frac{6}{125} \frac{2.20}{2}$); two miles east of Kandaira (Fedden, $\frac{6}{131} \frac{2.20}{2}$). Zone 2: gypseous shales, three miles east of Leilan coal-pit (Fedden, $\frac{6}{124} \frac{2.20}{2}$). Zone 4: Jhirak (Fedden, $\frac{6}{124} \frac{2.20}{2}$; Vredenburg, $\frac{h}{120} \frac{7}{2}$).

Comparison with other species.—Although this shell appears to be common, it does not occur amongst the material examined by d'Archiac and Haime, whose memoir only includes many-keeled species, such as *T. Deshayesi*, *T. Renevieri*, or with a prominent ridge, like *T. halaensis*. Outside of India, we are not acquainted with any eocene species exhibiting the same shape together with the same ornamentation: the forms already described, either in Egypt or in the Pyrenees, when they bear three keels, have convex whorls, or, if the whorls are flat, they are imbricated, and the keels are unequal.

Occurrence.—Upper Ranikot. Lower part of zone 2: gypseous shales, three miles east of Leilan coal-pit (Fedden, $\frac{6}{120}$ $\frac{200}{20}$). Zone 3: Jhirak (Fedden, $\frac{6}{120}$ $\frac{200}{20}$). Zone 4 hilly ground north by east of Petiani, north-west of Kotri, below the big scarp of white limestones (Fedden, $\frac{9}{120}$ $\frac{200}{20}$); Jhirak (Fedden, $\frac{6}{120}$ $\frac{200}{20}$; Vredenburg, $\frac{5}{120}$ $\frac{200}{20}$).

Comparison with other species.—This shell is evidently related to *M. fasciata* Lamk., of the Paris basin (middle and upper eocene); nevertheless, it is much less elongated, less pointed at the apex, more conoidal towards the base when full grown; the keels are more regular, and the striations of growth more conspicuous. *M. Locardi* Cossm., from the eocene of Diné in Egypt is less depressed and carries a fourth sutural thread. Lastly, *M. obruta* Locard, from Tunisia, differs from *M. Mecqueneni* both in shape and ornamentation.

Family: MELANIIDÆ (Lamarck) Gray

Genus: PLEUROCERA, Rafinesque, 1819.

PLEUROCERA VARIANS sp. nov. Pl. II, figs. 3-5.

Description.—Size moderate; shape narrow, elongated, spire turriculated, conical, acuminate at the apex, varying according to the age of the shell, consisting of numerous whorls whose height equals half their width, separated by superficial sutures, encircled by a small beaded thread; the ornamentation, which is variable, commences, on the first whorls, with rather crowded, small, straight ribs, amongst which are some broader spaces, interrupted posteriorly by an excavated band which extends up to the sutural thread, and occupies first one quarter, and, later on, one-third of the width of each whorl; at a farther stage, the ribs grow wider apart, and their anterior extremity ends in a spiny projection, while three or four very obsolete threads are developed on the posterior band; lastly on the latest whorls, the ribs disappear, and nothing remains but the spines occupying approximately the middle of the whorls, and united by a feebly projecting keel. The aperture does not appear to have been provided with a canal.

Dimensions.

Probable height	65 mm
Diameter	16 ..

Occurrence.—Upper Ranikot, lower fossiliferous band in zone 2, three miles east of the old coal-pit near Leilan (Fedden, $\frac{6}{120}$ $\frac{200}{20}$).

Comparison with other species.—It is on account of the similarity of the ornamentation of this fossil with that of *Cerithium spinosum*, Desh., that we have referred it to the genus *Pleurocera*: polymorphism of the spire is a characteristic feature of the Melaniidæ, so that our attribution may be accepted as correct, in spite of the very fragmentary condition of the specimens. The Indian species differs, however, from that

of the Cuisian of the Paris neighbourhood, owing to its less conical, more elongated and more acicular shape, and its more spinose body-whorl, which owing to the median position of its spines, differs so thoroughly from the preceding ones, that its fragments might be taken for those of a different species.

Family: *SOLARIIDÆ* Chenu.

Genus: *SOLARIUM*, Lamarck, 1799.

SOLARIUM VREDENBURGI, sp. nov., Pl. VII, figs. 34-36.

Description.—Small, discoidal: spire projecting, conoidal, consisting of four slightly convex whorls, separated by sutures encircled by an excavated band; the whorls are ornamented with numerous granular cords, often bifid, mingled with finer threads. Body-whorl very large, constituting nearly the whole shell, separated from the base by a sharp granular keel; base ornamented with granular unequal threads, which become broader towards the centre; umbilical funnel wide open, limited by a crenulated keel, showing all the spire whorls. Aperture trapezoidal.

Dimensions.

Height	6 mm.
Diameter	13 "

Occurrence.—Uppermost Ranikot, Jhirak (Vredenburg,) ^h₁?

Comparison with other species.—In their monograph on the Indian Nummulitic, d'Archiac and Haime have described two species of *Solarium*: one of them, *S. affine*, J. de C. Sow., a Gaj fossil, is distinguished from the Ranikot species by its narrower umbilicus surrounded by a crenulated ribbon instead of a keel, and by the ornamentation of its spire consisting of only a few distant grooves; the whorls of *S. Vredenburgi* are slightly convex, while *S. affine* has them flat. The second species, *S. euomphalides* d'Archi. and Haime, has rounded whorls forming steps; it has no peripheral keel, and belongs perhaps to another genus. *S. Vredenburgi* rather resembles *S. canaliculatum*, Lamk., from the Lutetian of the Paris neighbourhood; it is distinguished, however, by its more numerous basal threads, its more crowded crenulations round the umbilicus, its less canaliculated sutures encircled by a broadly excavated band, while the remainder of their surface is more convex.

Family: *PYRAMIDELLIDÆ* Gray.

Genus *PARYPHOSTOMA*, Bayan, 1873.

PARYPHOSTOMA CONVENIUSQULUM, sp. nov., Pl. VI, figs. 11, 12.

Description.—Small, narrow, elongated; protoconch constituting a small embryonic knob, smooth and obtuse; spire elongated, slightly conoidal, consisting of

eight convex whorls, whose height is equal to half their width, separated by deeply overlapping sutures, ornamented with six grooves deeply engraved into the shell, the intervals between them and the sutures constituting seven unequal ribbons whose width increases towards the posterior suture. Body-whorl short, including less than half the total height, rounded at its base which is ornamented like the remainder of the surface. Aperture wide, pyriform, obliquely situated, anteriorly produced and rounded, posteriorly angular, circumscribed by a broad swelling; outer lip oblique, externally bordered by a flattened sulcate margin, with a slight depression at the posterior angle; columella smooth, not excavated; columellar margin callous, well detached from the base.

Dimensions.

Height	80 mm.
Diameter	25 „

Occurrence.—Upper Ranikot, lower fossiliferous band in zone 2, three miles east of the old coal-pit near Leilan (Fedden, $\frac{O}{125} \frac{280}{24}$).

Comparison with other species.—D'Archiac and Haime have figured in their monograph, a fragment from the Punjab which they refer to *P. marginatum* Lam. (Pl. XXV, fig. 2.) but which is readily distinguished from our new species by its flat whorls and more conical shape. If that figure is correct, which is not quite certain, it indicates the presence in India of another species of *Paryphostoma*. *P. convexiusculum* differs from *P. minus* Desh. of the Paris eocene, by its narrower shape, its convex whorls, the number of its spiral ribbons, and the shallower notch at the posterior angle of its aperture; lastly, the swelling round the outer lip seems narrower and less prominent.

PARYPHOSTOMA? MESALIAFORME sp. nov., Pl. V, figs. 26, 27.

Description.—Small, narrow, elongated; spire turriculated, approximately conical, consisting of about eight feebly convex whorls, separated by very deep sub-eanaliculated sutures; the ornamentation consists of six concentric threads, regularly increasing in size towards the posterior margin; the last one, next the suture, is bifid and separated from the others by a broad excavated furrow. Body-whorl large, including two-fifths of the total height, with a rounded base upon which the threads persist, becoming more crowded towards the extremity, and with a thin intercalary thread in their intervals.

Dimensions.

Height	15 mm
Diameter	6 „

Occurrence.—Upper Ranikot, lower fossiliferous band in zone 2, three miles east of the old coal-pit near Leilan (Fedden, $\frac{O}{125} \frac{280}{24}$).

Remarks.—There is some doubt as to the generic position of this shell; it is quite distinct from the one already noticed, figured by d'Archiæ and Haime as *Paryphostoma marginatum* Lam.: its whorls are rather convex and ornamented with inequidistant cords separated by grooves, and not overlapping like the ribbons of a *Paryphostoma*; moreover, there is no indication of the thickened margin of outer lip, and the general appearance of the shell rather recalls that of a *Mesalia*. We would have referred it to the latter genus, were it not for the complete absence of any sinuosity of the striae of growth visible on the largest of the two specimens, where they seem slightly oblique and feebly convex. Consequently, the generic classification cannot be absolutely certain, so long as the aperture remains unknown. At any rate it is specifically distinct from *P. convexiusculum* whose almost perfect aperture leaves no doubt as to its correct generic attribution.

Family · HIPPONYCIDÆ

GENUS : HIPPONYX, DeFrance, 1819.

HIPPONYX ARCHIACI, sp. nov., Pl. VII, figs. 21, 22.

Description.—Size moderate, shape flattened, orbicular, discoidal; apex small, very excentric, with a minute projecting coiled nucleus; surface ornamented with concentric lamellæ of growth, somewhat irregular, crossed by very crowded, thin, regular, radiating ribs.

Dimensions.

Diameter. 27 mm.

Occurrence.—Upper Ranikot, upper fossiliferous band in zone 2, three miles east of the old coal-pit near Leilan, Band Vem plain east (Fedden, $\frac{1}{2}$ 280). Only one specimen.

Comparison with other species.—This interesting shell is distinctly related to *H. Heberti*, Deshayes, from the bartonian of the Paris basin; it is distinguished by its more delicate and more equal ribs, and its more marginal summit, with more coiled nucleus. *H. cornutus*, Desh. from the Lutetian, is more conical than *H. Archiaci* and still more delicately ornamented. The Indian shell does not seem to be referable to the genus *Capulus*, though we have not been able to verify whether the embryonic shell is ornamented, nor have we been able to see the muscular impression: the shell above described is fixed upon a sort of support externally convex, which has exactly the same outline as the shell, and a smooth external surface; it perhaps actually represents the calcareous support secreted by the animal.

Family: *NARICIDÆ*.

Genus: *NARICA*, Recluz, 1839.

(= *VANIKORO*, Quoy and Gaimard, 1832.)

NARICA SUBSPHERICA sp. nov., Pl. VII, figs. 18, 19.

Description.—Small, short, globular; spire short, conoidal, consisting of six to eight low, convex whorls, separated by deeply channelled sutures, ornamented with numerous deep grooves, distributed with much regularity, more crowded towards the margins than in the middle of the whorls. Body-whorl very large, sub-spherical, constituting almost the whole shell, with rounded base ornamented like the remainder of the shell, and perforated by a shallow umbilicus, which was incompletely covered by the columellar margin. Aperture wide, semi-circular; columella excavated, smooth.

Dimensions.

Height	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	13	mm
Diameter	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	12	"

Occurrence.—Uppermost Ranikot, Jhirak (Vredenburg, $\frac{5}{14}$).

Comparison with other species.—Although the apex is damaged, one can still recognise that the spire must have been lower than that of *N. alta*, Cossmann, from the Bartonian of the Paris neighbourhood; moreover, its grooves are much less crowded than in the European species, and it grows to a much larger size. The Lutetian species *N. Bonneti*, Cossmann, is not closely related for it has its spire even taller than *N. alta*, more convex, and a widely open umbilicus.

Family: *NATICIDÆ* Forbes.

Genus: *NATICA*, Adamson, 1757.

Section: *NATICINA*, Gray, 1840.

NATICA (NATICINA) HOLLANDI, sp. nov. Pl. VII, figs. 16, 17.

Description.—Small, short; spire scarcely projecting, conoidal, consisting of four very narrow, convex whorls, separated by deeply channelled sutures. Body-whorl very large constituting almost the entire shell, with very convex base perforated by a broadly open umbilical funnel. Aperture broad, semicircular, anteriorly rounded, posteriorly canaliculated. Columella almost rectilinear; columellar margin callous, closely fitting to the base, notched opposite the umbilicus which shows no trace of a funiculum.

Dimensions.

Height	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	10	mm
Diameter	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	8	"

Occurrence.—Lowermost beds of Upper Ranikot, undersearp of Jakhmari peak, Laki range (Noetling, $\frac{K}{964}$).

Comparison with other species.—The only *Natica* of d'Archiac and Haime's Memoir, that bears any resemblance to the present one (Pl. XXV, fig. 12), has been erroneously referred by them to *N. piglottina*, Lamk., which bears no resemblance to our species which is a *Naticina* without umbilical funiculum. It is narrower, and has a shorter spire than the specimen figured by d'Archiac and Haime. Amongst the species of the Paris basin, it may be compared with the Lutetian *N. pilula*, Desh., which is wider and has the outer lip more incised behind the umbilicus. *N. tenuicula*, Desh. (lower and middle eocene) has a taller spire.

NATICA (NATICINA) AMPULLINIFORMIS, sp. nov., Pl. VII, figs. 6, 7.

Description.—Size moderate; shape rather elongated although sub-globular; spire tall, conoidal, with convex, very narrow whorls, whose height is less than a quarter of their width, separated by deep, though linear sutures. Body-whorl very large, globose, constituting nearly the whole shell, with rounded base perforated by an inconspicuous umbilical fissure. Aperture wide, semilunar, obliquely inclined, anteriorly rounded, posteriorly canaliculated; columella smooth, slightly sinuous; columellar margin very callous, broadly spreading over the base, from which it becomes detached so as to cover the umbilical fissure, in which there is no trace of a funiculum.

Dimensions.

Height	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	25	mm.
Diameter	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	18	"

Occurrence.—Lowermost beds of the Upper Ranikot, two miles east of Kandaira, Vern plain east (Fedden, $\frac{a}{111}$).

Comparison with other species.—By its unusual shape and the absence of a basal rim, and specially by the shape of its aperture, not anteriorly expanded, this shell is related to the genus *Natica* rather than to *Ampullina*; and as it does not possess any funiculum extruding from the umbilicus, which is nearly closed, it should be referred to the sub-genus *Naticina*. D'Archiac and Haime have not described any shell resembling this species. Amongst the species of the Paris basin, there is scarcely any *Natica* with such a tall spire; *N. turbinata*, Desh. (Lutetian), has a more conical spire, and wider open umbilicus. *N. exerta*, Desh. (Lutetian), has a taller, more pointed spire, and is at once distinguished by its large umbilical funiculum.

Genus: MAMILLA, Schumacher, 1817.

MAMILLA ? BULLOIDES, sp. nov., Pl. VI. fig. 20.

Description.—Size moderate, shape ovoidal, spire very short, scarcely raised above the surface of the body-whorl, consisting of four very narrow, feebly convex whorls, separated by deep, channelled sutures; the striations of growth on the body-whorl are but slightly oblique.

Dimensions.

Height	.	.	.	.	.	.	.	.	.	.	25	mm
Diameter	.	.	.	.	.	.	.	.	.	.	23	..

Occurrence.—Upper Ranikot, upper beds of zone, 3, north of Leilan coal-pit (Fedden, ^{n 290}₁₂₉).

Remarks.—The determination of this fragment is very ambiguous, as the aperture is missing, and it is not possible to verify whether the base possesses the subcarinate umbilicus that characterises *Mamilla mamma*, Lea.

The striations of growth are neither oblique like those of a true *Natica* nor sinuous like those of an *Ampullina*. It is to be hoped that the discovery of better material will fix the generic attribution of this shell which possibly belongs to quite a different group.

Genus: CEPATIA, Gray, 1840.

CEPATIA ? OBLIQUISERIA, sp. nov., Pl. VII, figs. 13-15.

Description.—Size moderate, shape globose; spire short, conoidal, consisting of six very narrow, convex whorls, separated by deeply channelled sutures encircled by a more or less distinct shouldered band. Body-whorl very large, constituting almost the entire shell, rounded or torose, ornamented with imbricated, very oblique striations of growth; base convex, carrying in its centre an enormous callosity which probably extended over the whole umbilical region, but which is accidentally decorticated on one of the figured cotypes. Aperture broad, semi-elliptical, with a feeble parietal furrow; columella swollen in the middle; columellar margin constituting a thick swollen callosity, which probably covered entirely the umbilical region.

Dimensions.

Height	.	.	.	.	.	.	.	.	.	.	21	mm.
Diameter	.	.	.	.	.	.	.	.	.	.	20	..

Occurrence.—Uppermost Ranikot, Jhiruk (^{n 290}₁₂₉).

Remarks.—The attribution of this fossil to the genus *Cepatia* is not quite certain. On one of the two cotypes, the base could not be developed from the matrix. On the other one the columellar callosity seems to have been decorticated or corroded

in such a way as to expose the umbilical cavity through a notch whose outline cannot be interpreted as normal. Even supposing that the base really does exhibit the characteristic disposition of a *Cepatia*, it is to be noticed that the spire has its whorls separated by deeply impressed sutures, and does not recall the conoidal shape and confluent whorls of *C. cepacea* Lamk.; moreover, the oblique striae of growth do not bear much resemblance to the normally disposed ones of the European species, whose outer lip is practically vertical. The generic determination is therefore only provisional. The shell cannot be referred to the genus *Cernina* whose general outline is different, and whose spire is not striated. D'Archiæ and Haime's Memoir does not contain any figure resembling *C. obliquistria*: the fossil which they have named *N. cepacea* is much more depressed, and is only an internal cast.

Genus : SIGARETUS. Lamarck, 1799.

SIGARETUS OCHEROPHORUS, sp. nov., Pl. VII, figs. 24, 25.

Description.—Small, globose, expanded; spire short, conoidal, terminated by a smooth flattened protocone; it consists of three tall, very convex whorls, whose height is equal to half their width, separated by deeply channelled sutures, ornamented with pronounced regular grooves, the intervals between which are double their width. Body-whorl turbinate, very large, constituting nearly the whole shell, with a base that seems umbilicate, and upon which the ornamentation persists up to the centre. Aperture wide, oval, exceeding two-thirds of the total height. Outer lip greatly inclined.

Dimensions.

Height	.	.	.	.	.	.	.	.	.	11 mm.
Diameter	.	.	.	.	.	.	.	.	.	10 ..

Occurrences.—Uppermost Ranikot, Jhirak (Vredenburg).

Comparison with other species.—This species is more globose and less expanded than *S. clathratus* Gmelin (middle and upper eoene), of the Paris region, and its sutures are more deeply channelled; there are probably further distinctions in that part of the shell which we have been unable to study owing to its being half embedded within the matrix. It does not seem to be related to the lower eoene *Eunaticina Gouldi*, Recluz, which is more oval, with a much more prominent spire, and a very different ornamentation, so far as can be judged from the figure published by Recluz.¹

Genus : AMPULLINA, Lamarck, 1821.

AMPULLINA AULACOSPIRA, sp. nov., Pl. VII, figs. 3, 4.

Description.—Size moderate; shape rather depressed; spire elongated, conoidal, consisting of six feebly convex whorls, whose height scarcely equals half their width, separated by very deeply channelled sutures, so that each whorl rather overlaps the

¹ Journ. de Conch., 1851, Vol. II, p. 187, Pl. VI, figs. 5, 6.

preceding one. Body-whorl very large, feebly convex posteriorly, rounded at its base, with an almost closed up umbilical fissure out of which is extended a narrow callous "limb" (the spiral ridge that penetrates the umbilicus and is characteristic of the genus *Ampullina*) bordered externally by a keel. Aperture wide, oval, oblique, broadly channelled posteriorly; columella smooth, regularly excavated; columellar margin broad, callous, almost completely covering the umbilical fissure, and spreading anteriorly over the basal limb.

Dimensions.

Probable Height	.	.	.	.	.	.	.	.	.	30 mm.
Diameter	.	.	.	.	.	.	.	.	.	20 ..

Occurrence.—Upper Ranikot. Lower part of zone 2: amongst gypsaceous shales, three miles east of the old coal-pit near Leilan (Fedden ^{G. 220}₁₂₅). Zone 3: brown limestones of the hills east of Leilan coal-pit on the road to Unerpur (Fedden ^{G. 220}₁₂₇). Zone 4: Jhirak (Fedden ^{G. 220}₁₂₈; Vredenburg, ^{K 5}₁₁₆).

Remarks.—The spire of this species is similar to that of an *Ampullospira*; but the presence of a basal limb adjacent to the columella fixes its position within the genus *Ampullina*, though usually, the suture is not so deeply channelled amongst the species of the latter genus, the whorls being merely shouldered in front of the suture in such a manner as to give the spire a stepped appearance. The specimens of *A. aulacospira* are not in the condition of casts, and the floor of the sutural channels is easily observable, which would not be the case if these grooves resulted from the absence of the test. In d'Archiac and Haime's work, the only shell resembling this species is an internal cast which they have referred to *Natica longispira* Leym. (Pl. XXV, fig. 24): but it is much more rounded, with the body-whorl less compressed laterally, the aperture lower; moreover, one cannot ascertain the genus, the specimen being merely an internal cast, as it is essential to know the external characters of the base in order to identify the Naticidae.

AMPULLINA cf. SIGARETINA, Lam., Pl. VII, figs. 44, 45.

1853. *Natica sigaretina* † d'Archiac and Haime, *loc. cit.*, p. 251, Pl. XXV, figs. 19, 110.

The specimen which we have figured corresponds fairly well with the figure in d'Archiac and Haime's work: it is not much better preserved, and can only be somewhat doubtfully compared with the middle and upper eocene Parisian species which it resembles owing to its auriform, expanded aperture, its very short, feebly projecting spire, and the probable absence of an umbilicus, which seems to have been covered by a basal limb.

Dimensions.

Height	.	.	.	.	.	.	.	.	.	37 mm.
Diameter	.	.	.	.	.	.	.	.	.	32 ..

Occurrence.—Uppermost Ranikot, on the road south-west of Jhirak (Fedden, ^{G. 220}₁₆₅).

Genus: AMPULLOSPIRA, Harris, 1897.

AMPULLOSPIRA CONSTRICTA, sp. nov., Pl. VI, figs. 18, 19.

1853 *Natica cepacea*? Lamk d'Archiac and Haime, *loc. cit.*, p. 280, Pl. XXV, fig. 14.

Description.—Size moderate, shape helicoidal; spire short, as if accidentally compressed, consisting of few, convex, very low whorls, with a declivous band in front of the suture, rounded anteriorly by a rounded-off angle; surface smooth. Body-whorl rounded in front of the angle, up to the base which is imperforate. Aperture oval, oblique, holostomatous, though feebly produced anteriorly; outer lip thin, oblique, inclined in front of the axis ("antecurrent") towards the suture; columella thick, flat, feebly excavated.

Dimensions.

Height	30 mm
Diameter at the base	38 "

Occurrence.—Uppermost Ranikot, left bank of Indus opposite Jhirak (Vredenburg, $\frac{K 1}{327}$).

Remarks.—This helicoid shell can only be referred to the genus *Ampullospira* Harris (= *Euspira* Auct.) though its stepped spire is depressed, as if it had been flattened by pressing down its apex. The thickness of the bevelled columella confirms the generic attribution. The internal cast referred to *N. cepacea* Lam. by d'Archiac and Haime, probably belongs to this same species, but is not related to the genus *Cepatin*, as has been explained while dealing with *C. obliquistria*.

AMPULLOSPIRA ADELA, sp. nov., Pl. VI, figs. 28, 29.

Description.—Rather small, depressed; spire rather short, regularly conical, consisting of six to eight very narrow convex whorls, separated by channelled sutures. Body-whorl large, globose, including three quarters of the total height, with rounded base perforated by a rather broad umbilicus. Aperture narrow, oval, anteriorly rounded, posteriorly canaliculated; columella straight; columellar margin callous, closely fitting to the base.

Dimensions.

Height	13 mm.
Diameter	11 "

Occurrence.—Uppermost Ranikot, Jhirak (Vredenburg, $\frac{K 7}{145, 148}$).

Remarks.—This shell resembles neither *N. angulifera* d'Orb., nor *N. Flemingi* d'Archiac and Haime, figured by these authors in their monograph on the Indian nummulitic; the base, unfortunately, is not sufficiently preserved to make quite sure of its generic affinities, and the specific name selected expresses our uncertainty.

AMPULLOSPIRA? OWENI, d'Archiac and Haime, Pl. VI, figs. 22-23.

1853 *Phasianella Oweni*, d'Archiac and Haime, *loc. cit.*, p. 203, Pl. XXVII, figs. 3-4.1896 *Natica Oweni*, Oppenheim, Monte Postale, Palaeontogr., 43, p. 176, Pl. XIII, figs. 6-7.1900 *Natica Oweni*, Oppenheim, Priabona, Palaeontogr., 47, p. 197, Pl. XIV, fig. 3.1900 *Natica (Euspira) Oweni*, Oppenh. Egypt, Palaeontogr., 30, p. 205.

Description.—Large, rather narrow, very elongated; spire tall, regularly conical, consisting of eight to ten convex, low whorls, whose height is less than half their width, separated by deep sutures. Body-whorl large, including more than half the total height, with rounded base. Aperture rather wide, semicircular, anteriorly rounded, posteriorly encalciated; columella straight; columellar margin callous, detached from the base, almost entirely covering the umbilicus.

Dimensions.

Probable height	.	.	.	.	.	.	.	.	.	60 mm
Diameter	.	.	.	.	.	.	.	.	.	27 ..

Occurrence.—Uppermost Ranikot, Jhirak (Fedden, ^{a 2-6}_{121 a}).

Remarks.—There is no doubt about the specific identity of this species, which, indeed, is rather variable, judging by the figures published by d'Archiac and Haime; the spire in our specimens is slightly more elongated than that of the individual with the shell preserved, illustrated by our predecessors (fig. 3) who have stated that *P. Oweni* recalls certain Cretaceous shells—some of which have been classified in the genus *Phasianella*, others in the genus *Natica* (for instance *N. praelonga* Desh.) or rather *Ampullospira*, Harris. The eocene species so far described as referable to *Phasianella*, never reach such large dimensions. The characteristic features of *Ampullospira* (= *Euspira* auct., non Agassiz), cannot be recognised with certainty owing to the imperfect state of preservation of the mouth in our specimens. Nevertheless, the probabilities are in favour of its belonging to *Ampullospira* rather than to *Phasianella*. This is indeed the opinion several times expressed by Dr. Oppenheim, who believes that the same shell can be recognised in the Vicentino, at Monte Postale, and in Egypt. He has even united with it *Phasianella superstes*, Rauff, and *Natica syrtica*, Mayer, which we have omitted from our synonymy for want of sufficiently precise material, and because *P. Oweni* is the original Indian form.

According to d'Archiac and Haime, the species occurs commonly in Sind in a limestone with *Nummulites garancensis* which is evidently the oligocene Nari rock of that province; some of the other rocks cited by them as containing the same fossil may be of Ranikot age, while others are certainly Intotian. The latter age is that of the limestones from the Punjab and the Alveolina-limestone from Asia Minor in which the species is also stated to occur. It therefore exhibits in Southern Asia the same extensive vertical range which has been recognised by Dr. Oppenheim in the Mediterranean countries.

Family : *SCALIDÆ*, Broderip.

Genus : *SCALA*, Klein, 1753.

SCALA cf. *SUBTENUILAMELLA*. d'Archiac and Haime, Pl. VII, fig. 20.

1853. *Scalaria subtenuilamella*, d'Archiac and Haime, *loc. cit.*, p. 286, Pl. XXVI, fig. 0.

Description.—Fragment with very convex whorls, ornamented with very unequal, thin sometimes varicose lamellæ, sharply bent and knotted posteriorly, in front of the band that encircles the suture; the intervals between them appear to be smooth.

Occurrence.—Uppermost Ranikot, Jhirak (Vredenburg, $\frac{K}{178}$).

Remarks.—The fragment here described, differs from the type figured by d'Archiac. The angular bend of the lamellæ is situated further back, and the intervals do not appear to bear the spiral threads that punctuate the surface of *S. subtenuilamella* (a Gáj species according to Fedden, *Mem. G. S. I.*, XVII, p. 260). Nevertheless, for want of better material, we have avoided creating a new species, especially as owing to the absence of the aperture, we cannot even ascertain to what group of *Scalidæ* the specimen belongs.

Section : *ACRILLA*, Adams, 1860.

SCALA (*ACRILLA*) *COLPOPHORA*, sp. nov., Pl. VII, figs. 23, 23a.

Description.—Size moderate, shape narrow, slender; spire elongated, regularly conical, the spire angle being of a few degrees only; whorls convex, tall, their height being equal to seven-tenths of their width, separated by deep, oblique sutures; ornamentation consisting of thin axial lamellæ, widely spaced, oblique, sometimes sub-varicose, anteriorly inclined towards the suture of the previous whorl, decussated by extremely delicate, crowded spiral threads, which ornament the whole surface, but do not rise upon the axial lamellæ. Body-whorl large, with the base limited by a very obsolete spiral thread; the basal disc has indistinct boundaries, and is ornamented like the spire, the ribs folding over the neck. Aperture broken.

Dimensions.

Height of fragment	.	.	.	.	.	.	.	.	.	33 mm.
Width	.	.	.	.	.	.	.	.	.	10 "

Only one specimen.

Occurrence.—Upper Ranikot, upper part of zone 3, Jhirak (Vredenburg, $\frac{K}{180}$).

Comparison with other species.—This shell is evidently related to *S. gallica* de Boury, from the lutetian of the Paris neighbourhood, as shown by its narrow slender shape; it is distinguished, however, by its still taller whorls, with more oblique sutures, by its more crowded axial ribs, more unequal and sometimes varicose, by its

less distinctly circumscribed basal disc, the base being more convex. The Wemmelian species *S. curvilamella* Vinc., whose lamellæ are almost as crowded as those of *S. colpophora*, is differentiated by the manner in which the lamellæ are folded over the suture, thus producing an encircling ridge, and by its spiral threads which are much coarser than those of the Indian species. The other Parisian species are generally more depressed than *S. colpophora*, and this is the case too with *S. multilamella*, Bast., from the Burdigalian of Aquitaine.

Family *NERITIDÆ* Lamarck.

Genus: *VELATES*, Montfort, 1810.

VELATES *NOETLINGI*, sp. nov., Pl. VI, figs. 24-27.

1853 *Nerita Schmuddehana* d'Archiac and Haime, loc. cit., p. 278 Pl. XXV, fig. 4.

Description.—Large, flattened; spire non-projecting, forming a small knob made up of two or three flattened whorls. Body-whorl constituting the whole shell. Aperture large, semi-circular; outer lip externally thin, internally thickened by a large swelling rather distinct from the margin; columellar septum wide, slightly convex, not keeled on the side of the base; columellar margin very slightly convex, with six unequal bifid teeth, of which the middle ones are larger than the extreme ones, separated by narrower grooves slightly prolonged on to the basal callosity; this callosity encroaches on to the dorsal surface. Umbilical depression feebly indicated in front of the septum; pronounced semi-circular callosity bordering the internal portion of the outer lip, and contributing to contract the aperture.

Dimensions.

Larger diameter	40 mm
Transverse diameter	27 „

Occurrence.—Abundant in the three upper zones of the Upper Ranikot. Upper fossiliferous band in zone 2, three miles east of the old coal-pit near Leilan (Fedden, $\frac{G}{120} \frac{280}{120}$). Zone 3: east of Kandaina (Fedden, $\frac{G}{127} \frac{220}{127}$); hills east of Leilan old coal-pit on the road to Unerpur (Fedden, $\frac{G}{127} \frac{200}{127}$); north of Leilan coal-pit (Fedden, $\frac{G}{129} \frac{250}{129}$); Jhirak (Vredenburg, $\frac{K}{8,20} \frac{6}{8,20}$). Zone 4: Jhirak (Fedden, $\frac{G}{127} \frac{250}{127}$, Vredenburg, $\frac{K}{1,11} \frac{7}{1,11}$); left bank of Indus opposite Jhirak (Vredenburg, $\frac{K}{1,11} \frac{7}{1,11}$).

Comparison with other species and remarks.—We have very carefully compared the Ranikot *Velates* with those of Cuise-la-Motte, and find it impossible to refer them to the same species. It is in the characters of the aperture that we notice the most important differences: the Cuise fossil invariably bears on its columellar septum, eight small teeth separated by wider, unequal intervals, while the Ranikot form only bears six large teeth, sometimes bifid, and twice as wide as the intervals between them: this feature is well illustrated in figure 4. Pl. XXV, of

d'Archiac and Haime's monograph, which evidently represents a specimen from the Ranikot formation. The internal callosity of the outer lip contracts the aperture more than in the case of *V. Schmideli*, the umbilical depression is more excentric, and the shell is narrower than that of *V. Schmideli*.

The cast from the Salt Range figured by d'Archiac and Haime (Pl. XXV, figs. 3, 3a, of their monograph), and the specimens from Sind from Burma figured by Noetling (*Rec., G. S. I.*, Vol. XXVII, Pt. 3, Pl. I, II), belong to a later horizon than the Ranikot. We are unable to say whether they correspond with *V. Noetlingi* or with *V. Schmideli*, or whether they belong to a third species. The fossil from the Lutetian of Kachh described by J. de C. Sowerby under the name of *Neritina grandis*, was regarded by d'Archiac and Haime as identical with *V. Schmideli*; but Dr. Noetling makes it the type of a new genus "*Provelates*". We are unable to concur with Dr. Noetling regarding the establishment of this supposed new genus; it is founded on specimens whose sole peculiarity consists in having the apex entirely concealed within the posterior margin of the body-whorl. The extent to which the earlier whorls are enveloped owing to the relative obliquity of the axis of the final whorl, varies in different specimens of the same species: if the nucleus is sufficiently oblique, its apex must necessarily become concealed, and it is doubtful whether this peculiarity is even of specific value.

VELATES HALIOTIS, d'Archiac and Haime, Pl. VI, figs. 13-15.

1853 *Nerita haliotis*, d'Archiac and Haime, *loc cit*, p. 270, Pl. XXV, fig. 9.

Description.—Small, globose, amygdaloidal, slightly flattened on the surface bearing the spire. Body-whorl constituting the whole shell, ornamented dorsally with lamellar, axial threads, distributed at wide intervals, crossed by broad, very obsolete, spiral ribbons, whose intersection gives rise to small, rather regular crenulations. Aperture narrow, semi-circular. Columellar septum apparently serrated by large denticulations of which the two posterior ones alone are preserved on the type-specimen; basal callosity feebly convex, covering the whole of the inferior ventral face of the last whorl, so that the crenulations cease before reaching the periphery.

Dimensions.

Probable height	.	.	.	.	.	.	.	.	.	16 mm.
Transverse diameter	.	.	.	.	.	.	.	.	.	12 "
Thickness	.	.	.	.	.	.	.	.	.	9 "

Occurrence.—Upper Ranikot, upper part of zone 3, north of Leilan coal-pit (Fedden, ^{q. 260}/₁₂₉).

Remarks and comparison with other species.—The type, from the Punjab, figured by d'Archiac and Haime, agrees exactly with the shell above described; there is complete identity in the ornamentation of the dorsal surface, but our

predecessors were not able to observe the aperture, while our specimen shows a portion of it with the characteristic teeth of the genus *Velates*; the umbilical depression at the anterior extremity of the septum, also corroborates this generic attribution. The Lower Eocene of the Paris basin contains another ribbed species, *V. equinus*, Bezançon; but the Indian species is less hemispherical, more flattened on the side of the spire, and its erenulations are thinner, and less granular.

Family · *TURBINIDÆ* Adams.

Genus: *TURBO*, Linnæus, 1758.

Section: *PARUCHELUS*, Boettger, 1906.

TURBO (*PARUCHELUS*) *ADELUS*, sp. nov. Pl. VII, figs. 40, 41.

Description.—Small, trochoid or turbinate; spire rather long, regularly conical, consisting of four feebly convex whorls, whose height is less than half their width, separated by canaliculated sutures, ornamented with four equidistant raised keels, separated by broad intervals. Body-whorl very large, including two-thirds of the total height, with a rounded, imperforate base, upon which there are about ten keels becoming more crowded and granular towards the centre. Aperture rounded; columellar margin raised anteriorly into a smooth ear-shaped swelling towards which converge the last granular threads of the base.

Dimensions.

Height .	.	.	.	.	.	.	.	.	.	.	.	10 mm
Diameter	.	.	.	.	.	.	.	.	.	.	.	8 "

Occurrence.—Uppermost Ranikot, Jhirak (Vredenburg).

Comparison with other species and remarks.—This shell is related to *T. radiosus*, Lamk., a well-known shell from the Lutetian of the Paris basin; it is distinguished, however, by the absence of plications of growth between the keels that ornament its spire whorls, and by the relatively taller spire, giving the whole shell an elongated facies instead of the almost globular appearance of the Parisian species; consequently the aperture is narrower, and the ear-shaped swelling smaller. We consider that the Indian fossil should be referred to the same group as *Turbo cancellato-costatus*, Sandberger, which Mr. Boettger has made the type of a new sub-genus *Paruchelus*¹. The aperture is not quite free from the matrix, but on neither of the two specimens we have examined, do we find any trace of the pseudo-canal which exists on young individuals of *T. radiosus*. The specimens, in spite of their small size, appear therefore to be full-grown, as the canal of *Paruchelus* disappears entirely in adult shells.

¹ Zur Kenntniss der fauna der mittelmioocänen Schichten von Kostj in Krass-Szorenyer Komitat Hermannstadt, 1906 (*Verh. u. Mill. Stenben Ver. f. Naturwiss.*, LIV u. LV Bd.)

Family : *TROCHIDÆ*, Adams.

Genus : *DILLWYNELLA*, Dall, 1889.

DILLWYNELLA AULACOCYLUS, sp. nov., Pl. VII, figs. 37-39.

Description.—Small, flattened, rotiform; spire short, scarcely raised, regularly conical, ending in a smooth protocone with flattened nucleus; five convex whorls slowly increasing, narrow, separated by channelled sutures, bare of ornament. Body-whorl large, forming almost the whole shell, rounded at the periphery of the base. Aperture large, situated upon a very oblique plane; outer lip straight, inclined, rather thick; columella excavated, very obliquely situated inside the aperture; columellar margin constituting a broad lip impressed with a groove which terminates in a slope towards the anterior edge, and which broadens posteriorly, the outer limit of the columellar margin diverging widely from the internal curve of the columella.

Dimensions.

Height	5 mm
Diameter	8 „

Occurrence.—Upper Ranikot, lower fossiliferous band in zone 2, three miles east of the old coal-pit near Leilan (Feddén, ^{9 2 60}_{1.6 0 0}).

Comparison with other species.—This interesting little shell evidently belongs to the genus *Dillwynella*, Dall (= *Platychilus*, Cossm. = *Simoclitus*, H. and B. = *Tiburnus*, de Greg.) Its spire is much less prominent than that of the lutetian species from Paris, *D. labiosa*, Cossm., and its columellar groove is better marked; moreover, the umbilical perforation seems completely obliterated. The solitary specimen on which this species is founded is well preserved, so that there is no possible doubt as to the generic classification of the shell.

Genus : *CLANCULUS*, Montfort, 1810.

CLANCULUS PROBABILIS, sp. nov., Pl. VII, figs. 26, 27.

Description.—Size moderate, shape conical, spire short, conical, consisting of convex whorls separated by deep sutures, ornamented with five equal, equidistant granular threads. Body-whorl large, constituting almost the whole shell, with a flattened base upon which the ornamentation persists, though there is a tendency for the granulations to become obliterated; in the centre of the base is a large umbilical funnel, in the interior of which there are also some concentric threads. Aperture wide, rounded, obliquely situated, very much uncovered at the base; outer lip thickened, greatly inclined relatively to the axis; columella straight, toothed, at an angle with the anterior edge.

Occurrence.—Uppermost Ranikot, Jhirak (Vredenburg).

Remarks.—We hesitate somewhat in referring this elegant little shell to the genus *Liotia*: it somewhat recalls certain species of *Collonia* (*Conochilus*), but its peristome internally furnished with a wide rim, has no external varix. At the same time, the peristome margin is not raised externally as is usually the case with the eocene species of *Liotia* of the Paris basin, whose umbilicus is much wider open, and whose spiral keels are further apart. In spite of these differences, the affinities of our shell appear to be rather with the Delphinulidæ than with *Collonia*.

Genus: DELPHINULA, Lamarck, 1803.

DELPHINULA CORDIERI, d'Archiac, Pl. VII, figs. 30-33.

1850. *Delphinula Cordieri*, d'Archiac, *Hist. des progrès de la Géol.*, vol. III, p. 243.

1853. *D. Cordieri*, d'Archiac and Haime, *loc. cit.*, p. 287, Pl. XXVI, figs. 11-12.

Description.—Size moderate, spire short, conical, consisting of four or five rapidly increasing, flat, low whorls, separated by deep, almost horizontal sutures; ornamentation consisting of four or five thick, regular, equidistant cords, bearing tubular nodosities, and, in their intervals, a much more delicate intercalary thread; at the anterior edge of the whorls, is a more prominent, sharp keel, with short tubular spines. Body-whorl very large, constituting almost the whole shell, with very convex base ornamented with eight thick cords similar to those of the spire whorls, and revolving upon the internal surface of a broad umbilicus. Aperture small, circular; outer lip oblique; columella smooth, excavated; columellar margin thin, detached from the umbilicus.

Dimensions.

Height	.	.	.	.	.	.	.	.	.	.	13 mm.
Diameter	.	.	.	.	.	.	.	.	.	.	11 "

Occurrence —Uppermost Ranikot, Jhirak (Fodden, $\frac{a}{1260}$; Vredenburg, $\frac{K}{117}$); left bank of Indus opposite Jhirak (Vredenburg).

Comparison with other species.—As mentioned by d'Archiac, this species has some distant resemblance to *D. calcar* Lamk., from the Lutetian of the Paris neighbourhood; but its spire is taller, its aperture more rounded, the spines ornamenting its keel are shorter, its spiral threads fewer and less granular. In the case of *D. Regleyi* Desh., also a lutetian species, the spire does not show the grooves of *D. Cordieri*, and the base only has a few thick broadly spaced funicula. In their memoir on the Indian Nummulitic, d'Archiac and Haime have also compared the Indian species with *Turbo Damouri*, d'Archiac, from the Eocene of Biarritz, stating that "in addition to the discontinuous peristome of the latter and the want of an umbilicus, the flat portion of the whorls, along the suture, exhibits rounded curvilinear folds, occupying two-thirds of the surface, and in front of them, two granular threads only, this disposition

being quite different from that observed in the corresponding portions of *Delphinula Cordieri*."

Delphinula Cordieri is a typical member of the genus, while the other species described by d'Archiac and Haime, *Delphinula Coulthardi*, is a *Collonia* with umbilical funiculum.

Family: *FISSURELLIDÆ*, Risso.

Genus: *FISSURELLA*, Bruguière, 1791.

FISSURELLA FEDDENTI, sp. nov., Pl. VII, figs. 23, 29.

Description.—Size moderate, shape oval, oblong, unsymmetrical. Surface externally ornamented with thin, radiating, prominent ribs, widely spaced, the intervals occupied by a thinner intermediate rib; they are crossed by concentric threads slightly less prominent than the major ribs, and constituting, by their intersection with both sets of radial ribs, a lattice with square meshes; fissure elongated, with parallel margins, extending up to the apex.

Dimensions

Length	8 mm.
Width	5 "

Occurrence.—Uppermost Ranikot, Jhirak (Vredenburg, $\frac{K_1}{12}$).

Comparison with other species.—Although this shell is not in a perfect state of preservation, so that we have not been able to examine it internally, yet it seems quite distinct from the Parisian species owing to its ornamentation consisting of square meshes, non-squamose at the intersection of the ribs and concentric threads; moreover its fissure, adjacent to the apex, is more elongated and with more perfectly parallel edges than in most eocene forms.

Class: SCAPHOPODA.

Genus: *DENTALIUM* (Aldrovandus, 1618), Linnæus, 1758.

DENTALIUM VREDENBURGI, sp. nov., Pl. III, fig. 23.

Description.—Small, narrow, elongated, very slightly curved, almost straight; section circular; surface entirely smooth. Fissure invisible.

Dimensions.

Length of portion visible	15 mm.
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Occurrence.—Uppermost Ranikot, Jhirak (Fedden, ⁹²/₁₂₁).

Remarks.—The apex being embedded within the matrix, we have not been able to observe the fissure, so that the species cannot be accurately classified. Nevertheless it does not seem to belong to the section *Læridentalium* whose species are more elongated and straighter. It is more probably a *Furtiaria*, in which case the fissure should be rather elongated; it differs from *D. (Furtiaria) fissura* Desh. from the middle and upper eocene of the Paris region, principally by its smaller size, and its less oblique aperture.

PLATE I.

Fig. 1—4.	NAUTILUS SUBFLEURIAUSIANUS d'Arch.	. . . . .	Nat size.
Fig 5—10.	STYRACOTHEUTIS ORIENTALIS Crick	. . . . .	"
Fig. 11—13.	BELOSEPIA INCURVATA Cossm. and Piss.	. . . . .	"
Fig. 14—15	BULLA APICIALIS Cossm. and Piss.	. . . . .	"
Fig. 16—18.	ACERA STREPTA Cossm. and Piss	. . . . .	2/3
Fig. 19—20.	TORNATELLEA VREDENBURGI Cossm and Piss.	. . . . .	2/1
Fig. 21—22.	CONUS BREVIS Sow. ?	. . . . .	Nat. size.
Fig 23	CONUS SUBBREVIS d'Arch. and Haime ?	. . . . .	"
Fig. 24.	CRYPTOCONUS PERLIRATUS Cossm. and Piss	. . . . .	3/2
Fig. 25—28.	SURCULA VOYSEYI d'Arch. and Haime	. . . . .	3/2
Fig. 29—30.	SURCULA (ANCISTROSYRNX) VREDENBURGI Cossm and Piss.	. . . . .	3/2
Fig. 31—32.	SURCULA INDICA Cossm. and Piss	. . . . .	2/1
Fig. 33—35.	PLEUROTOMA (EOPLEUROTOMA) AMPHIBOLA Cossm. and Piss.	. . . . .	2/1
Fig. 36.	PLEUROTOMA (HEMIPLEUROTOMA) LUCALISTA Cossm and Piss.	. . . . .	4/1
Fig. 37.	DRILLIA ADELA Cossm. and Piss	. . . . .	3/1

GEOLOGICAL SURVEY OF INDIA

M. Cossmann et G. Pissarro.

Palaontologia Indica : Vol. III. Memoir No. 1. Pl. I

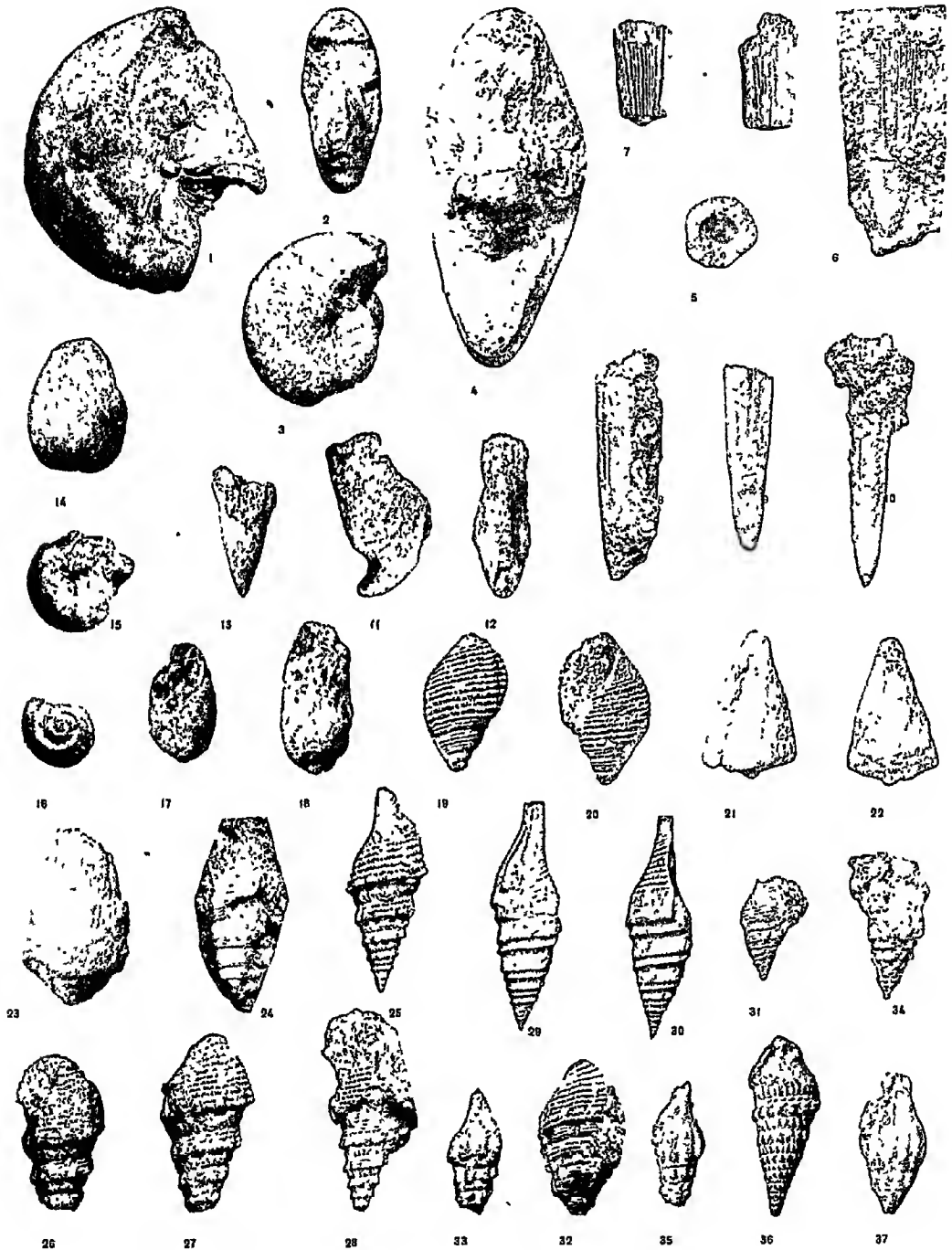


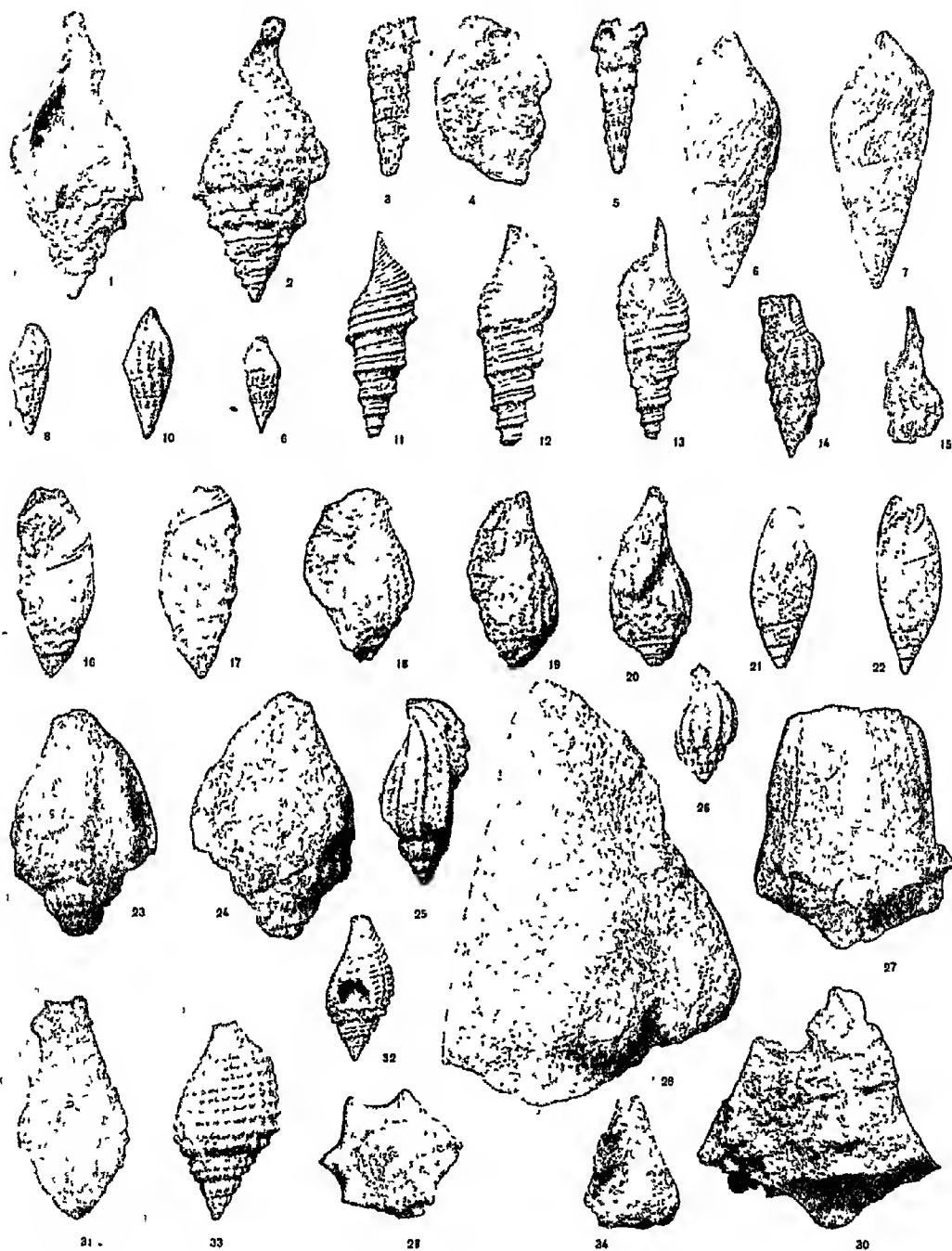
PLATE II.

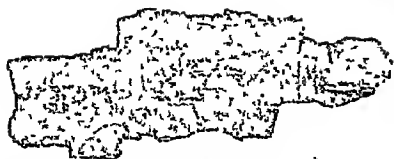
Fig. 1—2.	GENOTIA MURICIFORMIS	Cossm. and Piss.	.	.	.	.	.	Nat. size
Fig. 3—5.	PLEUROCERA VARIANS	Cossm. and Piss.	.	.	.	.	.	"
Fig. 6—7.	CRYPTOCONUS SURCULÆFORMIS	Cossm. and Piss.	.	.	.	.	.	"
Fig. 8—9.	DRILLIA JHIRAKENSIS	Cossm. and Piss.	.	.	.	.	.	2/1
Fig. 10.	"	"	<i>varietas</i>	.	.	.	.	3/1
Fig. 11—13.	SURCULA (APIOTOMA) HYPERMECLS	Cossm. and Piss.	.	.	.	.	.	2/1
Fig. 14—15.	PLEUROTOMA (EOPLEUROTOMA) JHIRAFENSIS	Cossm. and Piss..	.	.	.	.	.	2/1
Fig. 16—17.	ANCILLA (ALOCOSPIRA) INOPINATA	Cossm. and Piss.	.	.	.	.	.	3/2
Fig. 18	VOLUTOSPINA INTERCRENATA	Cossm. and Piss.	.	.	.	.	.	Nat. size.
Fig. 19—20.	"	"	<i>varietas</i>	.	.	.	.	"
Fig. 21—22.	OLIVELLA HOLLANDI	Cossm. and Piss.	.	.	.	.	.	3/2
Fig. 23—24.	VOLUTOSPINA NOETLINGI	Cossm. and Piss.	.	.	.	.	.	Nat. size.
Fig. 25.	HARPA MORGANI	Cossm. and Piss..	.	.	.	.	.	2/1
Fig. 26—31	LYRIA SIHURIENSIS	d'Arch. and Haime	.	.	.	.	.	Nat. size.
Fig. 27—30.	AULICINA HALMEI	d'Arch.	.	.	.	.	.	"
Fig. 32—33.	VOLUTOSPINA SYKESI	d'Arch. and Haime	.	.	.	.	.	3/2
Fig. 34.	AULICINA PUSIOLA	Cossm. and Piss.	.	.	.	.	.	2/1

GEOLOGICAL SURVEY OF INDIA

M. Cossmann et G. Pissarro.

Palaeontologia Indica: Vol. III. Memoir No. 1. Pl. II

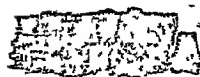




9a



10a



11a



14a



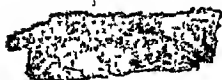
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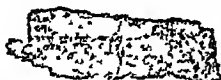
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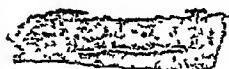
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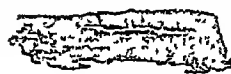
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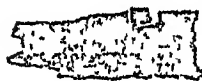
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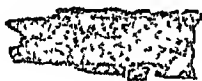
24a



24b



28a



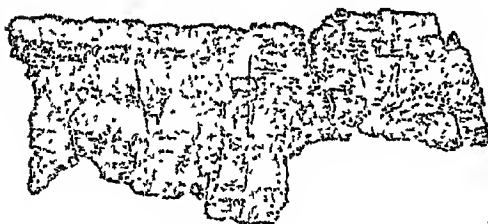
20b



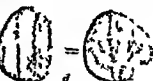
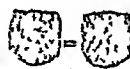
20



40a



33b



42

